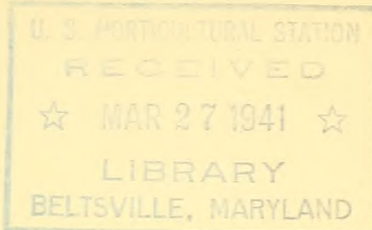


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THE PLANT DISEASE BULLETIN

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THE PLANT DISEASE SURVEY

Supplement 21

Diseases of Cereal and Forage Crops

in the United States in 1921

July 1, 1922

BUREAU OF PLANT INDUSTRY

UNITED STATES DEPARTMENT OF AGRICULTURE

IN THE UNITED STATES IN 1921*

Prepared by E. C. Stakman[†], Plant Pathologist,
Plant Disease Survey

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General statement

Most of the data which are summarized in this bulletin have been furnished by collaborators of the Plant Disease Survey. Many of the general conclusions also have been contributed in the same way. An attempt has been made to give credit not only for facts but also for ideas. The genesis of an idea cannot always be determined, but it is hoped that due credit always has been given. The compiler has interpreted facts as well as possible and has drawn conclusions which it is to be hoped are accurate. Wherever it has been possible collaborators have been quoted directly. Those referring to material contained in this publication are requested to cite the original contributor if possible.

* Summaries of diseases of cereal crops in the United States for the years 1918, 1919, and 1920 have been given in U. S. Dept. Agr. Plant Dis. Bul. Supplement 4: 119-159. 1919; 8: 1-81. 1920; 15: 115-176. 1921.

[†] Temporary appointment while on leave of absence from the Minnesota Agricultural Experiment Station and the Office of Cereal Investigations, United States Department of Agriculture.

Introduction

Cereal and forage crop diseases were not so destructive in 1921 as in some previous years, although the toll which they exacted from these crops was greater than it should be. It is evident from reports of collaborators that gratifying progress is being made in the control of easily preventable diseases such as most of the cereal smuts. Many collaborators call attention to the fact that cereal seed treatment is being practiced quite generally in those areas in which these crops are grown intensively. Better cultural practices no doubt contribute also to minimizing losses from some diseases, especially those which cannot be controlled easily by seed selection or seed treatment. Rapid progress also is being made in controlling diseases by the use of resistant varieties. This is true of such diseases as black stem rust of wheat and oats; the leaf rust of wheat; bunt of wheat; flag smut of wheat; foot rot (so-called take all) of wheat; spot blotch and foot and root rots of barley and, to some extent, of loose smut of wheat.

Collaborators are contributing considerable information on the epidemiology of diseases. Much information is accumulating on the factors which conduce to the development of disease - cultural practices, soil conditions, weather conditions, and crop geography. A fairly accurate study of the relation of the last two factors to the distribution and severity of diseases can be made from the Survey records. In fact, many valuable principles could be deduced if some of the records were more complete. The Office of Plant Disease Survey is undertaking such studies as rapidly as possible but must depend largely on the reports of collaborators for data. The Survey is making an effort not only to record the occurrence of diseases, but also to study their epidemiology.

Weather and diseases in 1921

The weather during the winter of 1920-21 and during the 1921 growing season was such as to favor the rapid development of many diseases early in the season and to inhibit their progress later. The almost unprecedentedly mild winter made it possible for such pathogenes as the rust to develop and spread almost continuously on fall sown grains. The high temperatures and fairly abundant rainfall in the spring also contributed to the rapid development of these diseases. However, the intensely hot, and, in many regions, dry weather in June and July ripened the cereal crops prematurely and checked the development of some diseases, such as the rusts, and probably prevented the development of others, such as wheat scab. Local variations, of course, occurred. While the hot weather checked the development of some diseases, the damage due to drought and heat was increased, thus complicating the estimates of losses. This probably is true of rusts. In many regions the small grain crops ripened so quickly - two weeks earlier than normal in some localities - that no accurate estimate could be made of the damage caused by diseases. In so far as possible the weather relations have been discussed in connection with each disease. It is to be hoped that more complete correlations can be established in the future.

DISEASES OF CEREAL CROPSWHEAT

Wheat production

The three accompanying maps (Figs. 27, 28, 29), show the geographic distribution of wheat in the United States in 1919. These are based on figures of the 1920 census and are adapted from maps supplied by the Offices of Farm Management and Cereal Investigations of the United States Department of Agriculture.

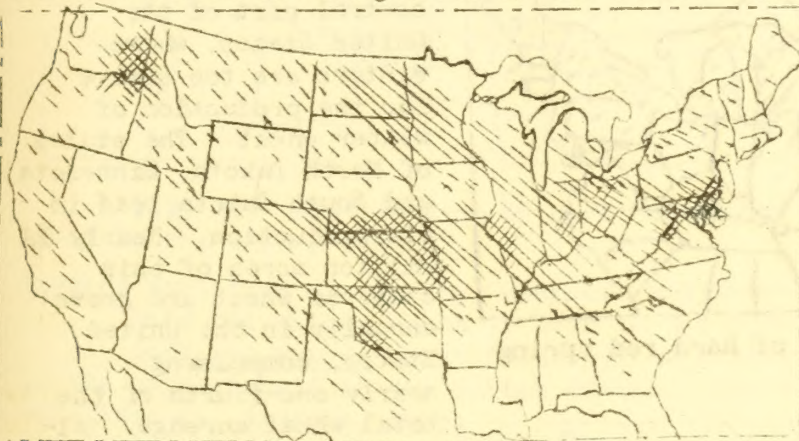


Fig. 27. Distribution of all wheat, 1919.

Fig. 28. Distribution of winter wheat, 1919.

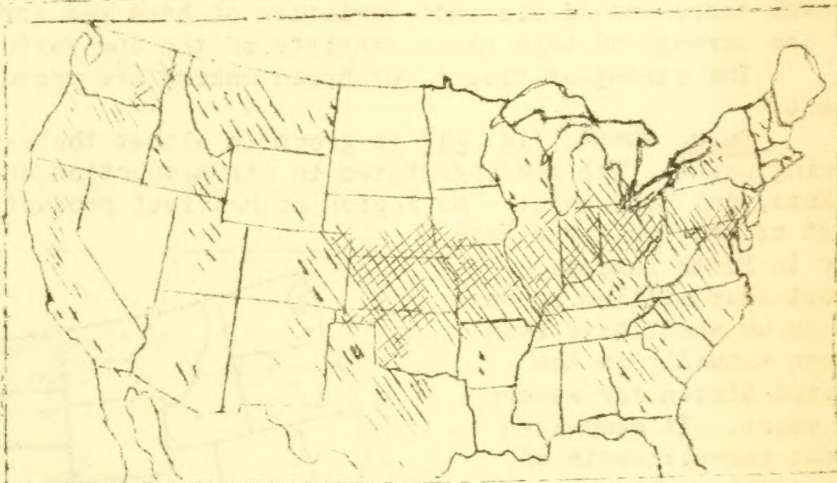
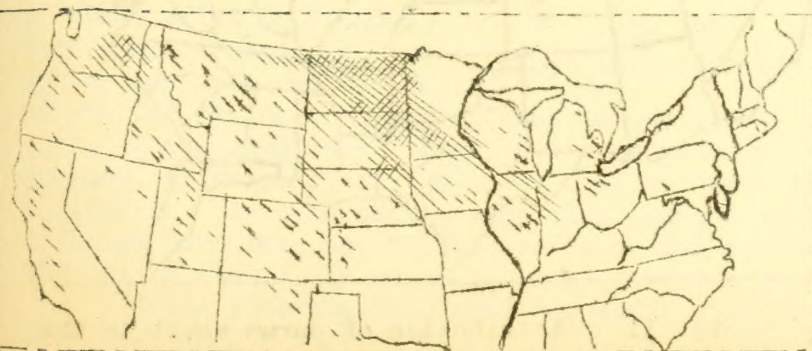


Fig. 29. Distribution of spring wheat, 1919.



Classes of wheat

The following general statements concerning the six commercial classes of wheat have been supplied by the Office of Cereal Investigations, and the text figures are adapted from maps supplied by the same Office.

Under the Official Grain Standards of the United States, wheat is graded in six commercial classes as follows: (1) hard red spring, (2) durum, (3) hard red winter, (4) soft red winter, (5) common white, and (6) white club.

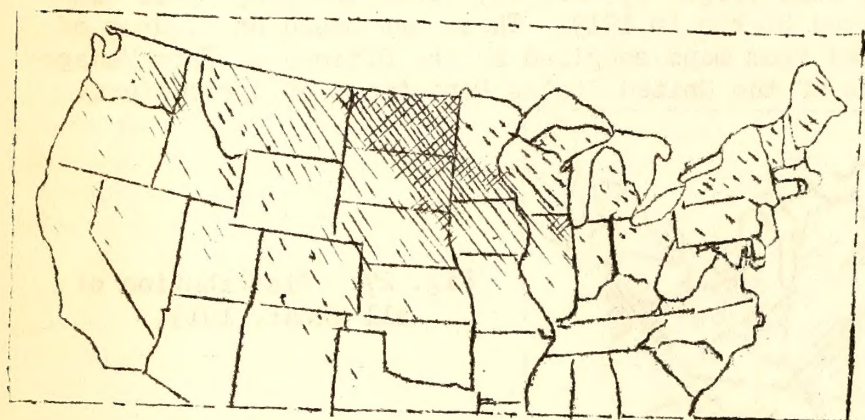


Fig. 30. Distribution of hard red spring wheat in the United States.

Hard red spring wheat (Fig. 30) is grown principally in the north central part of the United States, where winters are too severe for the production of winter wheat. The states of North Dakota, Minnesota, and South Dakota lead in its production. Nearly 14 million acres of this class of wheat are grown annually in the United States, comprising nearly one-fourth of the total wheat acreage. Al-

though there are 24 distinct varieties of hard red spring wheat, about two-thirds of the acreage of this class consists of the one variety, Marquis.

The strongest flours for bread making are produced from hard red spring wheat.

Durum wheat (Fig. 31) is grown in almost the same region as hard red spring wheat. The leading states in its production are North Dakota, South Dakota, and Minnesota. The region of heaviest production of durum wheat is just west of the Red River Valley in North Dakota.

About four million acres of durum wheat have been grown annually in the United States for several years. It comprises about one-sixteenth of the total wheat acreage. Arnautka and Kubanka are the leading varieties among the eleven commercial durum wheats grown.

Durum wheat

usually yields more than hard red spring wheat in this northern spring wheat region, due to its

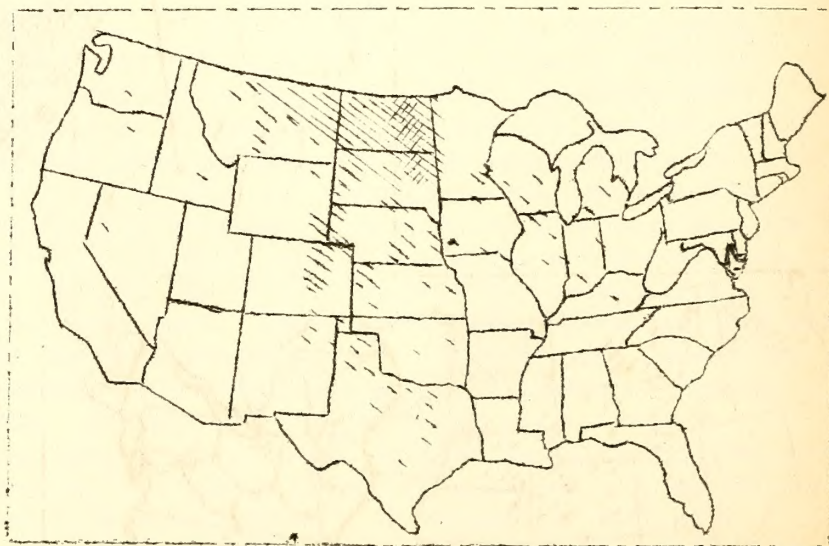


Fig. 31. Distribution of durum wheat in the United States.

greater resistance to drought and to black stem rust. Much of the durum wheat is ground into a granular semolina from which macaroni, spaghetti and other alimentary pastes are made. There is also a considerable foreign demand for this class of wheat.

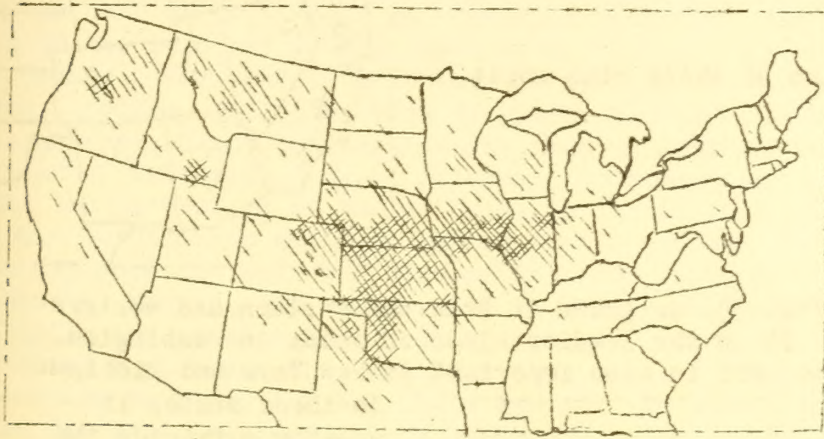


Fig. 32. Distribution of hard red winter wheat in the United States.

Hard red winter wheat (Fig. 32) is grown principally in the Central Great Plains area where dry summers and rather dry winters prevail. The states leading in its production are Kansas, Nebraska, and Oklahoma. Hard red winter wheat is not well adapted to humid sections. More than 17 million acres are grown annually in the United States, comprising less than one-third of the total wheat acreage. The

leading varieties are Turkey, Kharkof, and Kanred.

Hard red winter wheat is used in the manufacture of bread-making flour.

Soft red winter wheat (Fig. 33) is largely grown in the humid sections in the eastern half of the United States. The states leading in its production are Missouri, Indiana, Ohio,

and Illinois. About 16 million acres of this class of wheat are grown annually, comprising over thirty per cent of the total wheat acreage. About 65 varieties are grown, the principal ones being Fultz, Fulcaster, Mediterranean, Poole, Red May, and Red Wave.

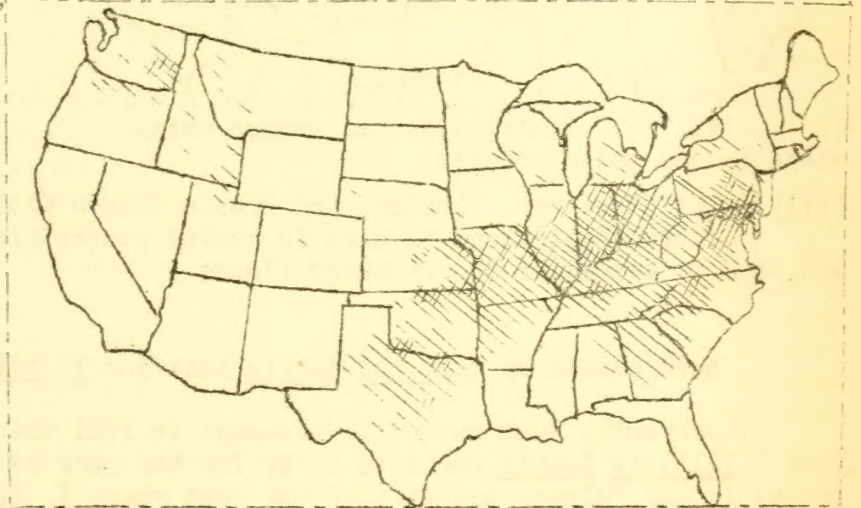


Fig. 33. Distribution of soft red winter wheat in the United States.

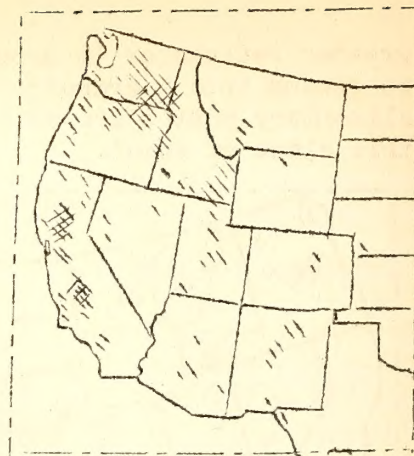
Soft red winter wheat is used in the manufacture of both bread-making and pastry flours. The flour from this class of wheat often is blended with that of hard red spring and hard red winter wheats for making a stronger bread-making flour.

White club wheat (Fig. 34) is grown only in the western part of this country, principally in the three Pacific Coast states, - Washington, Oregon, and California. In some sections of these states it outyields all other classes. Although more than one million acres of white club wheat are grown annually in the United States, it comprises less than two percent of the total wheat acreage.

White club wheat is used in making starchy flours for pastry or is

shipped to South America and the Orient.

Fig. 34. Distribution of white club wheat in the United States.



Common white wheat (Fig. 35) is grown in both the eastern and western parts of the United States. It is the leading class of wheat in Washington, California, Oregon, and Idaho, and is also important in New York and Michigan.

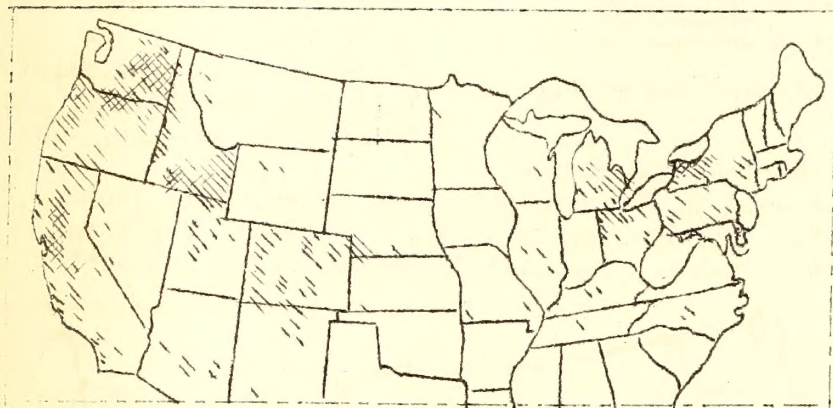


Fig. 35. Distribution of common white wheat in the United States.

In these states it usually outyields the other classes of wheat. Over three million acres of common white wheat are grown annually in the United States. It comprises somewhat more than five per cent of the total wheat acreage. More than 50 varieties of common white wheat are grown, the leading ones being Pacific Bluestem, Goldcoin,

Early Baart, Defiance, Dicklow, and Dawson Golden Chaff.

Common white wheat is used in making pastry flours and breakfast foods and to some extent in bread-making flours.

Bunt caused by Tilletia laevis Kuhn and T. tritici (Bjerk.) Wirt.

Apparently bunt caused less damage in 1921 than in 1920, or in an average year. Tilletia laevis seems to be by far the more common of the bunt fungi, except in the Palouse district of the West where T. tritici is more abundant. While it is not possible to make very definite statements on the basis of this year's reports, since many pathologists simply reported bunt and did not differentiate between T. laevis and T. tritici, it is quite evident that east of the Mississippi River most of the bunt is caused by T. laevis. The same thing is true in the spring wheat region. In Minnesota and the two Dakotas T. laevis certainly is more abundant, and T. tritici occurs only rarely. Which form is principally responsible for losses in the hard winter wheat area is not indicated in the reports of collaborators, although it probably is T. laevis.

Relative prevalence and importance of bunt in 1921

Bunt was unimportant east of the Mississippi River during the past year. Not a single state collaborator in that section reported more than 1% reduction

in yield on account of the disease. In the New England states no bunt was observed, and the same is true for South Carolina, Mississippi, Louisiana, and Wisconsin. While it is quite probable that the disease occurred, it apparently was so rare as to attract no attention whatever. In the middle western states and in the hard red spring wheat area there was scarcely an appreciable amount of damage. The same is true for the soft red winter wheat area, especially in Ohio, Indiana, Illinois, West Virginia, Kentucky, and Tennessee. However, it was more prevalent and destructive than in 1920 in the hard red winter wheat region of Nebraska, Kansas, Oklahoma, Colorado, and northern Texas. Learn reports that the percentage of bunted heads in fields in southeastern Colorado ranged from 5 to 55%, and Melchers states that in Kansas there was as much as 75% of bunt in some fields. The disease also was quite prevalent in the state of Coahuila, Mexico. It was present in practically all of the fields visited near Saltillo and in some fields the yield was reduced by at least 25%. It was reported that there was less bunt than usual in Montana, although the estimated reduction in yield for the state was 4%. In Idaho, Hungerford also reported that the yield was reduced by about 4% on account of bunt. It is said to be more severe in northern Idaho than in the southern part of the state. In Washington, according to Heald and others, as many as 50% of the heads in some of the fields were destroyed by the disease. There was said to be about the same amount as usual in Oregon, where the most found in any one field was 40%. Mackie states that bunt was quite general in California, but that there was less than in previous years. The reduction in yield in California was about 2%. As is well known, in the drier regions of these western states soil infection may occur.

The following reports summarize the situation and indicate the prevalence of bunt in the different parts of the country:

New York: The amount of covered smut, or bunt, caused by Tilletia foetens found in winter wheat seems to be negligible. One or two heads were all that could be found in any fields with the exception of two oases. In these two cases, which occurred in Niagara and Montgomery Counties, there was one and three percent of smut, respectively. In the spring wheat no covered smut was found. (R. S. Kirby).

Ohio: This trouble has been conspicuous by its absence this year and few fields were found with more than a trace of stinking smut. (Clayton).

Indiana: Local; not as much as in previous years. (Jackson).

West Virginia: Bunt was exceedingly slight. (Anthony Berg).

Kentucky: According to reports from millers, there is practically no bunt in Kentucky wheat this year. (Valleau).

Tennessee: (Observations made during April, May, and June in the vicinity of Knoxville, Murfreesboro, Columbia, Nashville, Jackson, and Union City.) Bunt smut was actually observed only in a few fields, and then in very small amounts. The damage should be considered very slight to none. Many growers treat the seed for the smut. (Sherbakoff).

Nebraska: Slight general infection throughout the state. Heavier than last year. One county reports 20% infection. (Goss).

Kansas: Bunt was very prevalent this year causing a great deal of damage. (Melchers and Stokdyk).

Stinking smut or bunt is quite generally distributed over the state again this year and is serious in some of the Kanred fields sown with smutty, untreated seed. (John H. Parker).

Oklahoma: (Perry, Newkirk, Medford, Enid, Cherokee, Alva, Fairview, Watonga, El Reno, Kingfisher, Norman, Oklahoma City, and Guthrie.) Covered smut of wheat, while not found in many fields, has been serious where found. For instance, one field near Fairview showed a loss of 10%, while one near Watonga showed a loss of 30%. (Stratton).

Colorado: In one county in the southeast corner of the state it was very general; reports were received stating a loss of from 5-55%. Farmers were very much concerned and desired to know of some means of control. It has been reported from several other localities in the state and a field was visited by the writer where there was a damage of 25%. The smut condition in the southeast corner of the state is the worst ever brought to my attention. (Learn).

Texas: Reports were received from parties at Benton, Texas that as high as 50% was present in some fields. There were fears of smut explosions in threshing machines and the question of using fans on the separators was considered but not put into practice. (W. H. Tisdale).

Washington: (Yakima Valley) Bunt of wheat is more prevalent this year than usual. (George L. Zundel).

Very little in spring seedings but some heavy infections in winter wheat. Fields showing 50% or over have been observed. (Heald).

Table 20. Highest percentages of bunt in individual fields, as reported by collaborators of the Plant Disease Survey, 1921.

State	: Highest :percentage ::	State	: Highest :percentage ::	State	: Highest :percentage
Kansas	: 75 ::	Oregon	: 40 ::	Delaware	: 6
California	: 65 ::	Pennsylvania	: 30 ::	Michigan	: 5
Washington	: 50 ::	Nebraska	: 20 ::	South Dakota	: 5
Texas	: 50 ::	Maryland	: 8 ::	New York	: 3

The following table (Table 21) shows the amounts of bunt during 1921 as compared with 1920:

Table 21. Relative amount of bunt in 1921 as compared with that in 1920.

Less than in 1920	:	More than in 1920	:	About same as in 1920
West Virginia	:	Nebraska	:	New York
Kentucky	:	Kansas	:	Virginia
Tennessee	:	Idaho	:	Maryland
Indiana	:	Oklahoma	:	North Carolina
Michigan	:	Colorado	:	Georgia
Minnesota	:	Texas (probably)	:	Arkansas
South Dakota	:	Delaware "	:	Illinois
Montana	:		:	Oregon
California	:		:	

There was about an average amount in North Carolina, Georgia, Arkansas, Illinois, Idaho, and Oregon, while Coons reports that there was less in Michigan than there is in the average year.

The map (Fig. 36) shows the prevalence and gives estimated losses caused by bunt in 1921.

Factors influencing the amount of bunt

1. Weather conditions

There are two possible reasons for the unusually small amount of bunt. It is quite probable that unfavorable weather conditions reduced the amount of the disease. Mackie calls attention to the fact that winter wheat did not become infected in California on account of an early, dry fall in 1920, and Essary, Hesler, and Sherbakoff mention also the effect of the dry fall of 1920 in Tennessee. The fairly dry spring probably accounts also for the relatively small amount of bunt in some of the hard red spring wheat states and in some of the soft red winter wheat states. Several other collaborators comment on the unfavorableness of the weather for the development of the disease. However, some of them point out that warm, dry weather prevented infection, while others suggest that cool, wet weather prevented infection. It would be desirable to make observations on the exact relationship between weather conditions and the development of the disease. In the hard red winter wheat area, in which the disease was more prevalent than it was in 1920, it is probable that high precipitation shortly after the wheat was sown may have been responsible for the heavy infection. Melchers mentions the probable effect of heavy precipitation in Kansas.

2. Use of seed treatment

In some states seed wheat apparently is more generally treated now than previously. Mackie points out that much of the seed wheat is treated in California and that this fact probably accounts for the reduction in the amount of bunt. Jennison states that this is true in Montana also, and Essary, Hesler, and Sherbakoff report that treatment is quite general in Tennessee. It is quite probable that the general use of methods of seed disinfection has been responsible for the reduction in the amount of the disease, since the Extension Divisions in several states have made campaigns during the past few years for

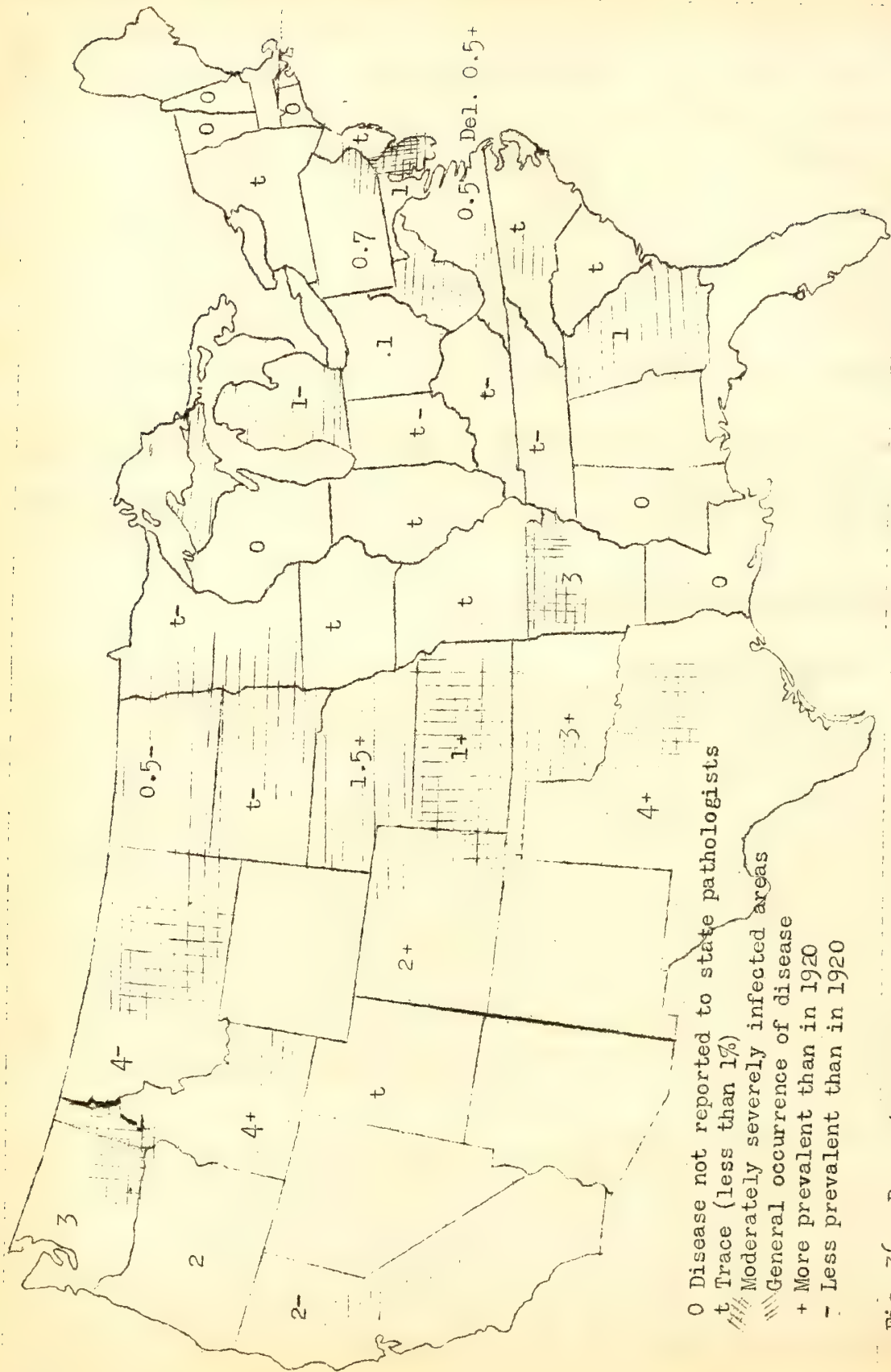


Fig. 36. Percentage reduction in yield from bunt of wheat in 1921, as reported to the Plant Disease Survey.

seed treatment. If this is true, it is highly gratifying. It would be extremely interesting to find out to just what extent the application of control measures has contributed to the desired result.

Control of bunt

Progress has been made in perfecting further the methods of seed treatment. Heald and Zundel have shown that seed injury caused by formaldehyde can be minimized by dipping the treated seed in lime water, made by adding one pound of lime to ten gallons of water (1, pp. 18-19).

The value of treating badly smutted wheat seed is shown strikingly by the following summary of results obtained by the Office of Cereal Investigations in experiments conducted at Arlington Farm, Virginia:

"The seed treatment experiment in which Seed Protecto and Formaldehyde were used on Purple Straw, C. I. 1915, inoculated with *T. laevis* spores by Dr. G. M. Reed was thrashed June 14. Yields on the six plats of 1/40 acre each in the test are uniform, as may be seen from the figures:

Check	Bu. per acre	Av. bu. per acre
Plat No. 1	4.6	
Plat No. 4	5.0	4.8
Formaldehyde treated		
Plat No. 3	15.8	
Plat No. 6	17.1	16.4
Seed Protecto treated		
Plat No. 2	13.8	
Plat No. 5	16.3	15.0

"Stinking smut balls composed at least 50% of what was obtained from the check plats." (J. W. Taylor, Cereal Courier 13: 134. July 20, 1921.)

Further experiments have been made on the use of chemical dusts for the control of bunt; and the indications are that the treatment of seed with copper carbonate dust or with dehydrated copper sulfate and lime will soon be used generally. The advantages of this treatment are quite obvious. Excellent results have been obtained in the Antipodes, and also in California, Washington, and Minnesota. It is quite probable that experiments have been made in other states also, but information is not yet available. The following statements summarize the situation.

Washington: Treatment with copper carbonate dust, two ounces per bushel recommended by Heald and Zundel (1, p. 18).

The following seed treatments were tested on two varieties of spring wheat that had been heavily smutted: Hypoform, chlorophol, copper carbonate dust, anhydrous copper sulphate dust, bluestone 1-1 sprinkle, sulphur and formaldehyde. Perfect control was secured by the following:

1. Hypoform	1 lb. to 5 gal. water	30 minutes
2. Chlorophol	1 part to 300 water	60 "
3. Copper carbonate dust	2 ozs. per bushel	
4. Anhydrous copper sulphate		
1 part, Calcium carbonate		
1 part	2 ozs. per bushel	
5 Sulphur	20 lbs. per bushel	

Seed treated with formaldehyde 1 lb. to 40 gallons water and the bluestone 1-1 sprinkle gave traces of smut. There was practically no reduction in germination in the case of hypoform, chlorophol, copper carbonate dust and anhydrous copper sulphate treatments.

Field tests secured by the Extension Plant Pathologist point to the probable value of the copper carbonate dust treatment in reducing the smut from soil contamination. Present information will justify the conclusion that the copper dust treatments are as effective as either formaldehyde or the bluestone steeps, more convenient to use and less injurious to the seed. (Heald).

California: Bunt was found in spots where the seed wheat had not been treated, one field being found with 65%, but, as a rule, the attack is reduced from that of last year. Seed treatment is more generally practiced. The average loss for the state may be given as 1.5% (Mackie).

Recent notes taken in the smut plots at Fresno indicate that copper carbonate and copper sulphate-lime dusts do not injure the seed in any way, but on the contrary, produce better stands and more advanced growth than non-treated seed. Laboratory examinations of bunted wheat sown in the soil between filter papers showed no germination of bunt spores where the seed was treated with the copper dusts but profuse germination of non-treated bunt spores. (W. W. Mackie, Cereal Courier 13: 38. Mar. 15, 1921).

The tests with chemical dusts for bunt control gave very encouraging results. Copper carbonate dust was slightly more effective in controlling bunt than the standard bluestone and formaldehyde treatments. Copper carbonate dust did not cause any appreciable seed injury, while both bluestone and formaldehyde caused considerable injury. (F. N. Briggs, Cereal Courier 13: 203. Sept. 10, 1921.)

Minnesota: The following tabular summary (Table 22) of results with copper carbonate dust is taken from an abstract by E. B. Lambert and D. L. Bailey (2). The experiments were made on spring wheat and oats at University Farm, St. Paul, Minnesota. It was found that copper carbonate used at the rate of two ounces per bushel, not only eliminated smut, but also increased the yield.

Table 22. Results of experiments conducted during 1921 at University Farm, St. Paul, Minnesota on the use of copper carbonate dust in preventing bunt of wheat and smut of oats.

Treatment	Wheat		Oats	
	Per cent :		Per cent :	
	decrease in: Per cent*		decrease in: Per cent	
	germination:	bunt	germination:	smut
Check	:	:	:	:
Concentrated	:	18.5	:	13
Formaldehyde (50-50)	:	:	:	:
Standard sprinkle (1-320)	:	2.1	:	3.0
	:	1.4	:	0.2
Copper-carbonate dust (2-4 oz.)	:	0	:	0
*Average of several tests.				

Resistance of varieties

Work still is in progress in various places on the development of varieties resistant to bunt. The following summary gives briefly the results:

Minnesota: This year 250 varieties were tested and of these several were almost immune to bunt, while a number are very highly resistant. Some, including some hard red spring wheats and some durums, are moderately resistant. (Stakman, Lambert and Bailey).

Oregon: Turkey Red rather highly resistant. White Club Hybrid types very susceptible. (Barss).

The following excerpts from the Cereal Courier summarize the results obtained by the Office of Cereal Investigations in Virginia and in California:

Virginia: The past season was a very favorable one for the development of bunt in this locality. Percentages in most of the varieties were high this year as compared with almost no infection last year. About 250 varieties and strains were tested to determine their behavior toward infection by both T. laevis and T. tritici, the two strains of the bunt fungus. Of these wheats, one strain each of Gladden and Red Hussar were free from T. laevis. Other strains showed from 5 to 70% or more of infection. Kanred showed a high degree of resistance to T. tritici but none of the varieties or strains was entirely free from infection. Very few varieties showed any marked degree of resistance.

The percentages of both species of *Tilletia* were lower in almost every case in 23 varieties of wheat sown October 12 than they were in the same varieties sown October 30. In this set of experiments the percentages of T. laevis were generally higher than those of T. tritici for the same varieties. None of these varieties was free from smut in either plot. (W. H. Tisdale. Progress report on cereal smut investigations at Arlington Farm, Virginia, 1921. Cereal Courier 13: 280-284. Nov. 30, 1921.)

California: Although it had not been noted previously, it appears that Hard Federation is quite susceptible to bunt. Bunt was observed most frequently on this variety and at Paso Robles a heavy infection was found in one of the two sowings. At this point frost had injured badly a portion of the plot with the remainder about normal. On the frosted portion a bunt infection of 25% was recorded, while on the unfrosted portion there was a 2% infection.

On the White Federation plot only a trace of bunt was found on both the frosted and unfrosted portions. (V. H. Florell (Chico) Cereal Courier 13: 106-107. June 10, 1921.)

Recent literature

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Loose smut caused by Ustilago tritici (Pers.) Jens.

Loose smut, as usual, was very generally distributed and some was present in practically all regions where wheat is grown. While most of the collaborators reported that the disease was general apparently it was not so destructive as in 1920. It was reported to be less prevalent than in the previous year in eight states, while in four it apparently was slightly more injurious than last season. The disease apparently did the greatest damage in Pennsylvania, Maryland, Virginia, West Virginia, Kentucky, Indiana, Illinois, Michigan, and Arkansas. The greatest reduction in yield probably took place in Michigan and Kentucky where Coons and Valleau estimated 5% and 4% respectively. Apparently loose smut does the greatest damage in the soft red winter wheat area. In the hard red winter wheat section of northern Texas, Oklahoma, Kansas, and Nebraska, the disease seems to be of little importance. In the hard red spring wheat region the disease also is of minor importance, except locally. In certain localities, for instance, in Minnesota in the west central part of the state, as many as 25% of the heads were infected. Many state collaborators report that the disease is insignificant and practically all of them state that it is not enough to justify any campaign for the use of modified hot water treatment. In some states, however, the disease seems to be increasing in severity, as is shown by the following comments:

New York: Loose smut presents a difficult problem to the New York farmer.

The loss averaged by counties in New York was 1.8%. However, this 1.8% loss may be a rather high field average, since most of the larger wheat-producing counties had from a trace to less than 1% of loss. This seemingly comes about by two factors as follows: First, No. 6 Junior is the principal wheat of the main producing area and this variety seems to be resistant to loose smut. This fact was pointed out to the writer by Mr. F. R. Perry of the Hickox-Rumsey Company, and the writer's subsequent observations corroborated this. There was seldom over a trace of loose smut in No. 6 Junior wheat, while in Dawson's Golden Chaff and Red Rock, the percentage of loose smut averaged between 3 and 4 per cent. The two highest percentages of smut found in any one field of several varieties follows:

Red Rock 19%, Wayne County; 12%, Monroe County
 Dawson Golden Chaff 26%, Oswego County; 19%, Niagara County.

The second factor is that the farmers in the main winter wheat producing area obtained their seed from cleaner fields. Very little hot water seed treatment was used by farmers questioned by the writer.

Loose smut seems to be a smaller factor in spring wheat than in winter wheat. In the true spring wheat region of New York state which lies just south of the St. Lawrence River, only about 10% of the spring wheat fields have over 1% of smut and most of the acreage had only a trace. (R. S. Kirby).

Indiana: Loose smut is more abundant, generally speaking, than usual when the whole state is taken into consideration. In this connection it has been interesting to note that wheat treated with hot water in 1919, while it gave a clean crop in 1920, is showing an abundance of smut this year, indicating that under favorable conditions for infection smut may increase very rapidly in treated wheat. It is practically impossible to get seed plots isolated and I am now inclined to think that smut may carry for some distance, especially in bright weather when there is a good breeze. I see no reason why this should not be true, though I do not believe we have very much data on how the loose smut will spread. (Jackson).

Idaho: Losses from loose smut of wheat have been increasing each year in the irrigated sections of southern Idaho. This year the amount of infection in various sections surveyed varied from one-half to 8%. Dicklow wheat, which is considered the best spring wheat for southern Idaho, appears to be very susceptible to loose smut. In connection with certification work conducted by the University Extension Division a considerable amount of hot water seed treatment has been carried on. In some instances individual farmers have treated their own seed but in most cases a member of the Extension Division has aided in the work. Uniformly good results have been secured. Loose smut has been controlled and no serious case of injury has been reported.

A rather extensive campaign for this type of treatment for the control of loose smut of wheat is being planned for this year. We are recommending treating only a small amount of seed for a seed plot. (Hungerford).

The highest percentages of infected plants in individual fields were as follows:

New York	- 26%	Kentucky	- 7%
Minnesota	- 25%	Maryland	- 8%
Michigan	- 20%	Virginia	- 8%
Pennsylvania	- 18%	Oklahoma	- 5%
Indiana	- 15%	South Dakota	- 3%
Mississippi	- 12%	Montana	- 3%
West Virginia	- 10%	Oregon	-.5%
Missouri	- 9%		

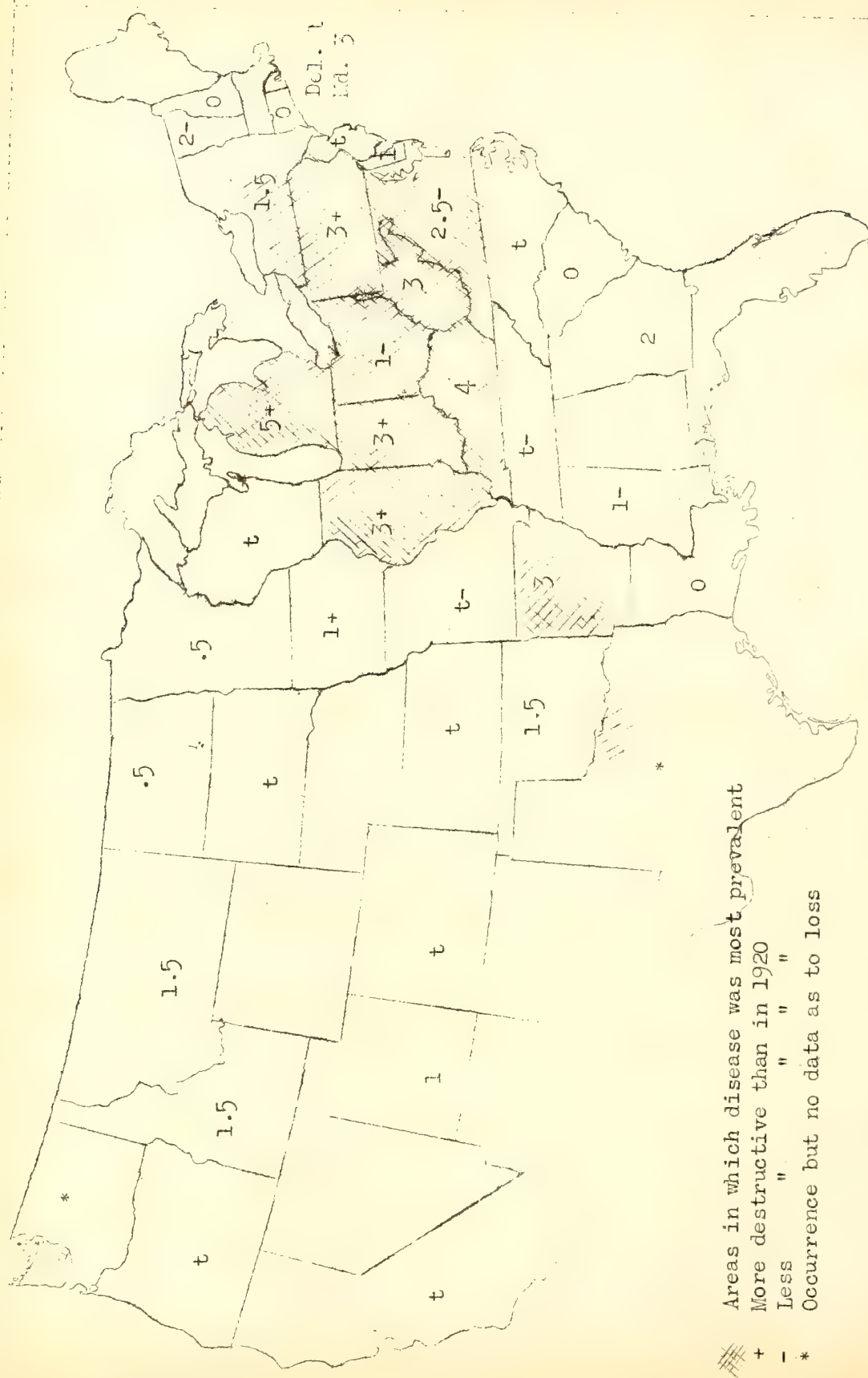


Fig. 37. Percentage reduction in yield from loose smut of wheat in 1921 as reported to the Plant Disease Survey.

The map (Fig. 37) and the following table (Table 23) give the estimated losses from loose smut in 1921.

Table 23. Losses from loose smut of wheat in 1921.

Approximate Percentage loss	:	States
5%	:	Michigan
4%	:	Kentucky
3%	:	Pennsylvania, West Virginia, Maryland, Arkansas, Indiana, Illinois
2.5%	:	Virginia
2%	:	Vermont, Georgia
1.5%	:	New York, Oklahoma, Montana, Idaho
1%	:	Delaware, Mississippi, Iowa, Utah, Ohio
Less than 1%	:	North Carolina, Missouri, Wisconsin, Minnesota, North Dakota, South Dakota, Kansas, Colorado, Washington, Oregon, California. (In all these less smut than in 1920.)

Several collaborators suggest that unfavorable weather conditions at flowering time of the wheat in 1920 were responsible for the rather small amount of smut during the past season. Sherbakoff suggests that wet weather at flowering time possibly may explain the small percentage of smut in Tennessee, while Barss and Mackie suggest that in Oregon and California, respectively, the dry air probably prevents abundant infection.

Susceptibility of varieties to loose smut

There are sharp differences in varietal susceptibility. Stratton states that in Oklahoma Kanred and Black Hull Turkey are the least susceptible, while Thomas reports that in Ohio smut is particularly prevalent in Goons. Coons states that in Michigan loose smut is the most common cause for the rejection of inspected fields of Red Rock. Bolley observes that in North Dakota both the durum and bread wheat varieties are susceptible. Fromme states that the occurrence of the disease in Virginia is determined chiefly by the range of wheat varieties and that it is an important factor in all sections in which Stoner is the predominant variety.

Very probably one reason why loose smut seems to be particularly destructive in the soft red winter wheat region is the susceptibility of many of the varieties commonly grown in that region.

The following table (Table 24) summarizes comments made on varietal susceptibility this year. In the Plant Disease Bulletin Supplement 15, pages 121-124 is given a complete summary of data which had been accumulated in cereal disease surveys up to the time of the publication of that Supplement.

Control of loose smut

The modified hot water treatment for the control of loose smut is not used extensively. Most collaborators report that the disease is not destructive enough

Table 24. Varietal susceptibility of wheats to loose smut.

Susceptible		Resistant	
Variety	Authority ²	Variety	Authority
Fultz ¹	: Tisdale ³	:: Fulcaster ¹	: Tisdale
Mediterranean	: "	:: Harvest King	: "
Currell	: "	:: Mammoth Red	: "
Dawson	: "	:: No. 6 Junior	: Kirby
Golden Chaff	: " ; Kirby	:: Leap's Prolific	: Fromme
Goens	: " ; Thomas	:: Fultz ¹	: "
Red Rock	: Kirby	:: Trumbull	: Clayton
Stoner	: Fromme	:: Kanred	: Stratton
Red Wonder	: Fromme	:: Black Hull Turkey	: "
Fulcaster ¹	: "	::	:
Red Wave	: Clayton	::	:
Portage	: "	::	:
Dicklow	: Hungerford	::	:

1 = Reported both as susceptible and as resistant - probably due to different varietal strains, according to Tisdale.

2 = Data furnished in reports to Plant Disease Survey unless otherwise specified.

3 = W. H. Tisdale, in Cereal Courier 13: 280-284. 1921.

to warrant a campaign for seed treatment, and the cumbersomeness of the treatment probably also acts as a deterrent. A special questionnaire on this subject was sent to collaborators and replies were received from most of them. Apparently the hot water treatment is used but little in the following states: Maine, New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Kentucky, Tennessee, South Carolina, Georgia, Mississippi, Louisiana, Oklahoma, Arkansas, Wisconsin, North Dakota, Iowa, Nebraska, Kansas, Montana, Arizona, Washington, Oregon, and California.

The following comments are made by collaborators in those states in which some organized work has been undertaken:

Pennsylvania: We have conducted demonstrations for control of loose smut of wheat by the hot water method for two years with most satisfactory results. This year demonstrations were conducted in Jefferson, Armstrong, Lebanon, and Juniata Counties. In Armstrong County 500 bushels of wheat were treated. If conditions are favorable about 90 bushels can be treated a day by the barrel method. Perfect control of smut was secured this year from treatments in the fall of 1920. Unfortunately, no yields were secured but Mr. P. R. Smith, the demonstrator, tells me that the stands were perfect and evidently the increase in the yield on the treated fields was much greater than the per cent of smut present in the untreated fields.

We can say with considerable confidence that the method is not used by farmers in this state to any extent except in relation to our extension demonstrations. (Orton).

Maryland: We use the modified hot water treatment simply as demonstrations. So far we have had very good results..... We usually

treat not more than ten bushels for demonstration. (Temple).

Virginia: During the past season one of these plants was established in Nelson County and 300 bushels of wheat were treated. Demonstrations of the hot water treatment were given in Amherst County and 60 bushels in all were treated. (Fromme).

West Virginia: The treatment has been used to some extent in the eastern part of the state but only in small areas and under the supervision not only of the county agent but of Mr. Berg and Mr. Sherwood. The treatment was given under rather difficult conditions since there was no central point where a large quantity of water could be easily held at a constant temperature but the results were very good. Germination was apparently not affected in at least 50% of the cases. In other cases the grain was injured somewhat. We made germination tests beforehand and suggested using increased quantities of seed which took care of any weak grain. (Giddings).

Ohio: This control method is used in Ohio very little. About 150 bushels were treated last fall in six different counties in demonstration work made by the Extension representatives in cooperation with the county agents. All of the wheat at the Ohio Agricultural Farm at Wooster, except the checks, was treated. I know of no instance where individual farmers are attempting any control of loose smut of wheat. (Roy Thomas).

Indiana: The first use of hot water treatment in this state was in 1917 when six demonstrations were put on, using the sack and basket method. During 1918 a number of individual demonstrations were conducted in various parts of the state which also attracted considerable attention. These, together with the successful results of Mr. East, resulted in eight central treating plants being established in the fall of 1918. This was increased to 20 in the fall of 1920 and was further increased last fall. In the meantime the sack and barrel method is still used for preliminary demonstrations in counties where the interest has not yet been worked up to a point of establishing a central treating plant. In this connection it is interesting that all of the 20 treating plants which were used in 1920 were again used in 1921. Some variation of the method originally used by Mr. East has been made in other counties. For example, a portable treating plant has been used in Posey and Knox Counties. This is essentially the same sort of apparatus that Mr. East has been using, but so arranged that it can be taken by truck from township to township, the steam usually being supplied by a traction engine.

In general, I may say that the method has been a decided success and I think that there will be still more central treating plants used in the fall of 1922. Naturally a number of problems needing investigation have arisen in connection with this work. In the summer of 1921, for instance, it was noted that seed treated in the fall of 1919 showed a rather high percentage, in some cases as much as untreated seed. This occurred under conditions where it seemed evident that the smut must have carried considerable distance during the growing season of 1920.

We feel that the method should be used only in connection with the seed plot system except perhaps under certain unusual conditions. (Jackson). (See F. J. Pipal. Hot water treatment for seed wheat. Purdue Univ. Dept. Agr. Ext. Bul. 100: 1-16. Fig. 1-5.)

Missouri: Although a few men treated last year, yet the practice is not at all widespread. It is hoped that more farmers will treat their seed this year. I have had one or two letters from growers asking for information about the method of preventing loose smut. (Hopkins).

Illinois: A few years ago, a number of the progressive farm advisers of the state thought it would be advisable to assist their farmers in the treating of wheat for loose smut. However, after they had learned the expense of the necessary equipment for this work and saw the need for very careful work throughout the operation, they changed their minds. Loose smut in Illinois is probably not destructive enough to merit the installation of treating plants. If the hot water method is used very much in this state it is in a very limited way and probably only by investigators. (Dungan).

Minnesota: Demonstrations carried on in several places in Otter Tail County. Results were excellent. Smut was practically eliminated from treated lots and in some of the checks there was as much as 20% of smut. (R. C. Rose).

Idaho: Extensive campaign being planned. (Hungerford)

It is quite probable that seed treatment would be used more generally if the method were simpler. Several years ago experiments were made by the Office of Cereal Investigations and the Minnesota and Wisconsin Experiment Stations on the effect of pasteurization. The results were very promising and indicated that the smut could be eliminated from seed lots by soaking from two to three hours in water at a temperature of from 45° to 48° C. Tisdale's summary in the Cereal Courier indicates that excellent results have been obtained recently by similar methods.

"Further use of the simplified hot water treatment has given gratifying results. It has a number of advantages over the method which has been in common use. In brief, it (1) reduces the period of treatment about one-half; (2) eliminates three of the four immersions and the labor incident thereto; (3) completely controls loose and covered smuts as shown by two years' results (4) increases the yield, whereas the old method decreases it (one year's results), and (5) reduces the cost of treatment about one-half.

"The steam treatment methods have also given promising results. The object has been to devise methods for treating large quantities of grain with steam and drying with commercial grain dryers. Small models of several standard makes of machines have been used. It has been found possible to maintain a saturated atmosphere at a very constant temperature by employing very simple devices and alterations on the

machines. Complete control of both loose and covered smut has been obtained without seed injury. The cost of treatment on a commercial scale will be reduced if the method continues to prove successful.

"Varietal tests were not undertaken on a large scale this year, but those which were conducted show that some of the popular varieties, such as Fultz, Mediterranean, Currell, Dawson, Golden Chaff, and Goens, are very susceptible, while Fulcaster, Harvest King, and Mammoth Red showed a marked degree of resistance.

"Physiological studies on the parasitism of U. tritici were recently initiated. There is considerable evidence to show that infested plants do not suffer a lessened capacity to resist winterkilling." (W. H. Tisdale. Progress report on cereal smut investigations, Arlington Farm, Virginia. Cereal Courier 13: 280-283. 1921.)

Flag smut caused by Urocystis tritici Koern.

Flag smut was discovered in the United States for the first time in 1919. As a result of the survey made in that year the disease was found in 33 fields on 20 different farms in Madison County, Illinois. The total infested acreage was approximately 825. In 1920 the disease was found in 111 fields covering an area of approximately 2500 acres. The total infested area was about 47 square miles but the disease was not known to occur outside of Madison County.

Flag smut survey in 1921.

In 1921 the Plant Disease Survey, in cooperation with the Office of Cereal Investigations of the Bureau of Plant Industry of the United States Department of Agriculture, and with the Illinois State Department of Agriculture, made an intensive flag smut survey in the portion of Illinois bordering on Madison County and in the Mississippi Valley in Tennessee and Missouri. An attempt was made to ascertain whether the disease occurred in other regions also. Special surveys were made by collaborators in many of the wheat-growing states and many posters as well as other publicity material were distributed. Flag smut was found only in Illinois, but an infested area was located in St. Clair County just south of Madison County where the smut had not been seen previously. (Fig. 38).

The infested area in Madison County (Fig. 39) is near Granite City and is about thirteen miles long, and between six and seven miles wide. In 1921 the area was extended somewhat and the quarantined zone was increased from forty-seven square miles to sixty-one. In 1921 the disease was found in 120 farms out of 200 inspected, and was found in 211 fields, 100 more than in 1920. This may not be due entirely to an actual spread of the smut, but partly to the fact that the survey was carried on more intensively in 1921 than in 1920. The men got into the field earlier and had a better opportunity of locating the disease.

The infested area in St. Clair County is about $3 \times 3\frac{1}{2}$ miles in extent and there are 57 infested fields on 30 different farms. There are 3 fairly distinct areas of infestation: One, by far the largest, is near the town of Dupo, another near Cahokia, and still another near East St. Louis. About one-third of the infested fields are in bottom lands of the Mississippi River and

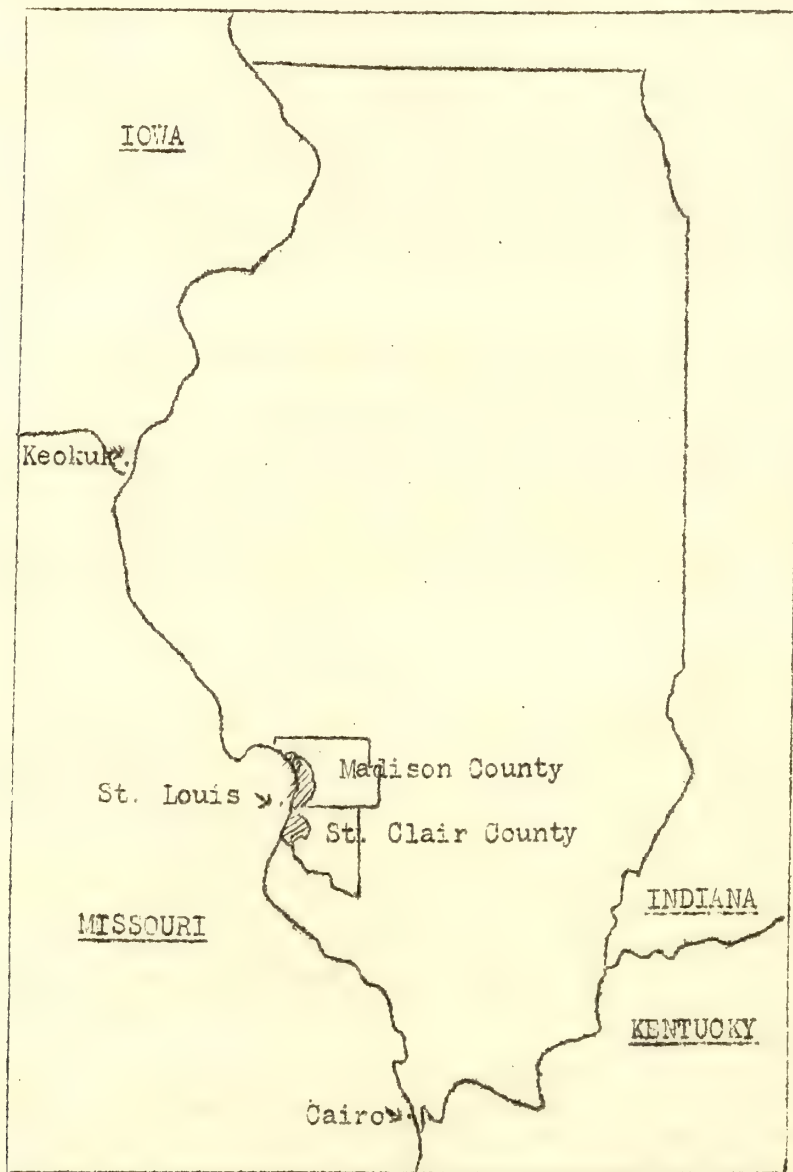


Fig. 38. Location of areas in Illinois quarantined on account of flag smut. Shaded portions represent infested areas.



- = Quarantined line for 1921
 - - - - - = " " " 1920
 .. = Dots represent infested fields in 1920
 x = Infested fields first observed in 1921

Fig. 39. Flag smut area in Madison County, Ill., in 1920 and 1921 showing the increase in size of the infested area.

the others are on high, uneven land.

The following summary of the work done and the results obtained in Dupo section proper, is taken from a special report prepared by R. J. Haskell:

Size of territory covered - - - - -	About 45 sq. mi.
Total area of farms visited (acres) - - - - -	4817-1/2 A.
Number fields inspected - - - - -	122
Number farms with flag smut - - - - -	28
Acreage of farms with flag smut - - - - -	2916 A.
Number fields with flag smut - - - - -	50

Prevalence and importance of flag smut

While the known region of infestation apparently is increasing, the disease does not seem to be becoming more destructive within the infested area. Although flag smut can do considerable damage, as is indicated by the fact that in one field 15% of the plants were infected, apparently it is being held in check, or even being reduced on individual farms. This is due very largely to the fairly general practice of treating the seed and of rotating crops. The situation with respect to the destructiveness of the disease is summarized by Haskell in his special report as follows:

"Regarding the seriousness of flag smut in both of these districts, it may be said that it is not causing farmers any loss. That is, less than 1% of flag smut has been found in all but about ten fields. However, it should be explained that lack of time prevented an accurate determination of the percentage of disease in the various fields. The field men were concerned principally with determining whether or not the disease was present and if found at all in a given field, the field was not inspected further but was reported as being infested. In a few fields spots were found where as high as 10% affected plants were observed and in one field in the Dupo section an average of 15% was recorded. One individual count in this field was as high as 25%. This was of course an exception and is the worst field that has thus far been found. It goes to show, however, that flag smut can become serious under the conditions existing in western Illinois.

"There seemed to be a tendency for the disease to occur in spots and in some cases these spots were located near old straw piles where the threshing was done last year. Only one field was found in the Dupo area where more than a trace of the disease occurred and that field had 15%. In the Granite City Section about nine fields with from 1-2% were observed."

Agents in the dissemination of flag smut

Not a great deal is known about the dissemination of the pathogene. It has been suggested that it might be spread by water, but evidence accumulated

during the past season indicates rather clearly that water is an agency of only secondary importance in spreading the fungus. This is shown by the fact that a small island just south of Chautau Island, one of the most severely infested areas, grows about 500 acres of wheat, and in spite of the fact that it is flooded each year, no flag smut has been found. Furthermore, in the Dupon section about two-thirds of the infested fields are on land approximately 200 or 300 feet above the River. Wind and threshing machines seem to be responsible for spreading the fungus to a great extent, and infection from the soil is very important. Smut developed in one field which was sown with seed obtained from Kentucky, indicating that infection must have resulted from the germination of spores in the soil. It seems quite probable, in view of what already is known about the dissemination of spores in the air, that many flag smut spores must be blown to considerable distances by the wind. Recently smut spores of various kinds were caught on spore traps, exposed on an airplane flying at an altitude as high as 12,000 feet. On one ordinary microscope slide exposed in this way, 60 smut spores were found in one clump. No flights for the purpose of exposing spore-traps were made near the flag smut infested area, but there would seem to be no reason whatever why these spores might not be blown to great distances during dust storms; or whirlwinds could carry the spores up several hundred, or even several thousand feet, where they could be blown easily for many miles by the upper air currents.

Control of flag smut

The methods of control consist in (1) quarantines, (2) seed treatment (3) use of resistant varieties, and (4) cultural practices. The control program which has been adopted in Illinois is summarized as follows by Haskell in his special report:

"The Illinois State Department of Agriculture has decided on a vigorous control program to be carried out under the leadership of P. A. Glenn. This program in general is as follows:

"(1) All grain is to be treated at the threshing machine as it comes from the separator by spraying it with concentrated formaldehyde at such strength and rate as will kill the smut spores and make the seed useless for planting purposes. One pint of formaldehyde and one pint of water to twenty-five bushels was used last year, but it is probable that this amount of solution will be applied to thirty-five bushels this year.

"(2) Threshing machines are not to be used for threshing grain grown outside of infested areas if such machines have been used inside of the areas.

"(3) Threshing machines inside of areas must be disinfected with formaldehyde before threshing oats or other grains the straw of which the farmer wishes to preserve.

"(4) Machines that have been used for threshing wheat must be disinfected with formaldehyde at the close of the season.

"(5) Farmers are required to plant such varieties

as the State Department of Agriculture shall recommend. These varieties will be those that have shown immunity during the past few years.

"(6) Seed is to be treated with copper sulphate and lime before planting in the fall.

"(7) Wheat straw is to be burned by September 1, 1921."

The flag smut situation in the United States

The following recapitulation of the situation in this country is taken from Haskell's unpublished report on the results of the flag smut survey in 1921:

"1. Another area where flag smut occurs has been discovered in Illinois. This is known as the Dupo Section and contains 57 infested fields on 30 farms.

"2. The original Granite City Section has been enlarged and extended this year by further survey, one hundred additional infested fields being found.

"3. Careful search for the disease on both sides of the Mississippi River from Cairo, Illinois to St. Louis, Missouri failed to reveal its presence except in the Dupo Section, and scouting in parts of the Missouri and Illinois River Valleys yielded negative results.

"4. Flag smut at present is not causing any appreciable loss, most of the fields showing only a trace, and about ten fields showing 1%. One field, however, contained 15% smut, manifesting the possibilities of the disease to become serious in this country.

"5. No evidence pointing to dissemination of the fungus by the river water was obtained. It is probable that spread in this way is not at all important. Observations of the field men show that the wind, threshing machines, and seed are the most likely agents of spore dissemination.

"6. The disease does not seem to have increased in severity during the last three years, but it seems to have been spreading steadily to new fields.

"7. Territory outside of, and adjacent to, the quarantined areas should be watched carefully in the future to prevent the escape of flag smut.

"8. The Illinois Department of Agriculture is conducting a vigorous campaign the most important phases of which are,- disinfection of grain at the separator, regulation of threshing machines, the planting of resistant varieties, and the disinfection of seed grain by the copper sulphate method."

The flag smut situation in Australia

The following summary of the Australian situation was prepared by Mr. R. J. Noble of the New South Wales (Australia) Department of Agriculture,

a graduate student at the University of Minnesota and collaborator with the Office of Cereal Investigations:

"Flag smut occurs in all of the wheat growing areas of Australia with the exception of Western Australia, i.e., it is recorded from the states of South Australia, Victoria, New South Wales, and Queensland and extends over an area of about eight million acres. Infection up to 70% has been recorded in individual fields in Victoria, and during this 1921-1922 season losses up to 25% have been reported in certain areas of New South Wales. The average annual loss is estimated at about 3% for the whole of Australia representing a deficit of about three million bushels.

"Because of the longevity of the spores and because practically all infection occurs from inoculum already in the soil, present control measures are at best only palliative.

"Infection is always heaviest in the long season varieties and particularly when sowing is made in a dry seed bed.

"Seed treatment by pickling in one and one-half per cent copper sulphate, effective as it is in the control of bunt, is, however, of no value if the soil is already infested with flag smut.

"Control measures on the whole are as follows:

"1. Crop rotation by which at the very least, two seasons intervene between successive crops of wheat while every effort is made to conserve soil moisture to induce germination of spores.

"2. Burning of stubble in affected fields.

"3. By feeding only disease-free hay and stubble to stock.

"4. By sowing mid season and late varieties wherever possible in a well prepared seed bed.

"Practically all the best commercial varieties, - e.g., Federation and Hard Federation types - are in the long season class and at the present time the short season resistant varieties cannot replace them except in a few of the districts throughout the wheat growing areas.

"Experiments are in progress to test the efficiency of an extension of the dusting treatment in its relation to this disease."

Varieties resistant to flag smut

Since the spores may live in the soil for a considerable length of time it is quite evident that seed treatment, even with copper sulphate and lime, cannot be depended upon to control the disease entirely. For this reason, it is necessary to rotate crops and to use resistant varieties whenever possible. A list of resistant varieties is given on pages 126-128 in the Plant Disease

Bulletin, Supplement 15, issued May 1, 1921. Since that time, according to W. H. Tisdale, it has been found that Red Wave is not as resistant as it was originally considered to be. The other varieties, however, were as resistant in 1921 as they previously appeared to be. The following varieties seem to be suitable for use in the infested region of Illinois: Turkey Red (several strains), Fulcaster, Early May, Gypsy, and Nigger. Dungan recommends the use of Turkey 10-100, and Nigger.

Recent literature

Tisdale, W. H. and M. A. Griffiths. Flag smut of wheat and its control. U. S. Dept. Agr. Farmers' Bul. 1213: 1-6. May 1921.

Stem rust caused by Puccinia graminis Pers.

Stem rust (Fig. 40) was quite prevalent in 1921, but apparently it did not do as much damage as it did in 1919 and in 1920. In the New England states there was very little rust. In fact, none was observed in Connecticut or in New Hampshire, while in Vermont there was practically no loss from the disease. It is reported as having been fairly abundant, however, in Rhode Island. In New York, Pennsylvania, New Jersey, Delaware, Maryland, and West Virginia rust caused very little damage: the reduction in yield is estimated as a trace only. Both in New York and in Pennsylvania there was less rust than there was last year; in West Virginia there was a little more; in Virginia, according to Fromme, there was considerably more rust and it practically destroyed the wheat in some fields. Fromme's comment that the occurrence of rust was correlated definitely with the presence of native Berberis canadensis, is particularly interesting. All through the southeastern states the damage from rust was slight.

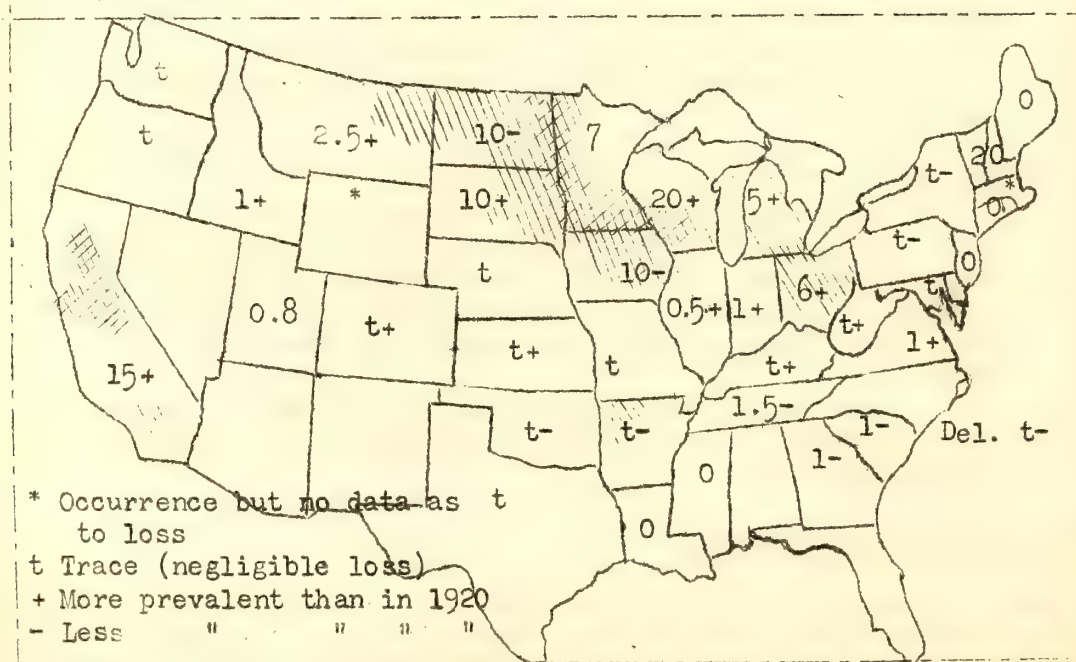


Fig. 40. Stem rust of wheat in 1921, prevalence and percent loss according to reports to the Plant Disease Survey.

In part of the soft red winter wheat region there was more rust than there was in 1919. In Kentucky, Ohio, Michigan, Indiana, and Illinois, stem rust was both more prevalent and apparently more destructive than in 1920, although the aggregate losses were rather small. Clayton estimates that the total yield in Ohio was reduced by 6%, while Coons estimates a 5% reduction for Michigan. In Indiana the loss was 1%, while the reduction in Illinois is estimated at .5%. The reduction in yield in Wisconsin is estimated by Vaughan to have been 20%; some of this undoubtedly was on spring wheat.

In the hard red winter wheat region rust was abundant but it developed too late to do much damage. Elliott reports that it was more prevalent than usual in northwestern Arkansas, although there was less for the state as a whole than there was in 1919. It is reported also as having been less severe than usual in Oklahoma, while in Texas it was apparently about average, or possibly slightly above the average. Melchers reports that there was more rust in Kansas in 1921 than in 1920, although the damage was slight. In Colorado there was much more rust than there was in the previous year although not much damage was done. The damage in the hard red winter wheat region would have been much greater had it not been for the fact that the grain matured early and thus escaped the rust.

The greatest damage was done in the hard red spring wheat region. The rust appeared earlier than usual and was fairly prevalent throughout much of this section by June 20. However, the unusually early harvest made it possible for the wheat to escape the greatest damage from rust. It was almost impossible to estimate accurately the reduction in yield due to rust in the hard red spring wheat region because the excessively hot weather and drought not only injured the wheat, but also caused it to ripen so early and so quickly that it was very difficult to differentiate between rust and weather injury. In most of the hard red spring wheat region, wheat was harvested two or three weeks earlier than in a normal season. In Idaho, Hungerford states that there was more rust than usual both in the northern part of the state and in the irrigated sections of the southern part. According to Barss there was a little more than usual in Oregon, but the loss was only a trace, and the same is true of Washington. In California, Mackie estimated that rust reduced the yield by 15%, which is considerably greater than the reduction in the average year. It is quite probable that the average reduction in yield in the two Dakotas and Minnesota was between 10% and 15%. Jennison reports that the rust was much more prevalent and destructive in northeastern Montana than it has been for many years, although the reduction in yield for the entire state was only 2.5%.

The following comments regarding the occurrence and severity of rust attacks are especially interesting.

Virginia: Quite localized, and determined by occurrence of native barberry, Berberis canadensis. Some fields too poor to warrant threshing, and fed for hay. (Fromme).

West Virginia: Quite severe in the southeastern part of the state. Mr. Berg found good evidence of its spread from sections where the barberry (Berberis canadensis) was found to sections some distance away. The disease evidently less serious and in an earlier stage in the distant fields. (N. J. Giddings).

Tennessee: (Observations made during April, May, and June in the vicinity of Knoxville, Murfreesboro, Columbia, Nashville, Jackson, and Union

City.) Stem rust in many fields could not be found at all, even in the latter part of May and early in June, that is, shortly before harvest time this year. Usually an occasional plant affected with the rust could be found, especially on the border plants that yet remained green. Only in one field, on the farm of the Normal School at Murfreesboro, the rust was found, June 4, in a severe form in the low part of one field. The rest of the field, in the higher part of it, was nearing full maturity and was practically free from the rust. The wheat specimens brought in by the Knox county agent and his information in regard to other fields showed that some fields in east Tennessee were seriously injured by the rust, the damage in some exceptional fields being as high as 30%. The damage for the state would be considered at about 3%. (C. D. Sherbakoff).

Arkansas: More than usual, probably little damage. (Elliott).

Kansas: A heavy infection was under way when hot, dry weather prevented its further spread. (Melchers).

Ohio: This rust appeared late but from June 10 on it was found in the majority of fields visited. It did little damage over the state as a whole. In certain sections of South Central Ohio, however, the attack was severe and the loss heavy. (E. E. Clayton).

In June it was not at all difficult to find a large sprinkling of black stem rust in almost any wheat field in central and western Ohio. However, it was not generally present to a damaging degree. A very few instances of serious damage from black stem rust have been reported. All reports of serious damage from stem rust, which have been investigated to date, have shown that escaped common barberries were responsible for the attacks. It is hard to account for the general light sprinkling of black stem rust over extensive areas. (John W. Baringer).

Indiana: By the end of July the barberry survey of all counties in the extreme northeastern part of the state has been completed, thus rounding out a block of territory made up of northeastern Indiana, southern Michigan, and northwestern Ohio. All of DeKalb and Steuben Counties and the balance of LaGrange County were covered during this month. During this period some of the most striking cases of the spread of rust from the barberry which have been observed since the campaign began in Indiana were discovered. In one instance a single bush in the front yard of a farm in DeKalb County was found to have spread rust to about 25 acres of wheat within a radius of a mile. One of these pieces of wheat consisting of about 15 acres on the farm of the man owning the barberry bush, was being thrashed on the day the bush was discovered. No further argument was necessary to convince the men that were thrashing this rusted grain that the barberry should be removed. (R. J. Hosmer).

Rust local; severe only near barberries. (Jackson).

Illinois: Heat wave hastened ripening and reduced rust damage. Direct connection between presence of rust in northern Illinois and presence of infected barberries. (Dungan and Tehon).

Michigan: Southeastern Michigan, Monroe County, slight, if any Lenawee, limited outbreaks, damage 5%, very slight except in direct relation to barberries where reduction in yield was 40%. Northern and Central parts of Lower Peninsula, slight rust. Upper Peninsula, severe, loss in general 15%. (Coons).

Wisconsin: More rust in vicinity of escaped barberry. Winter varieties little damaged. Damage checked by drought. (Vaughan).

Minnesota: First report on wheat about June 15, from Dakota County. Found on grasses on May 29. The rust came early and developed rapidly until the excessively hot weather in June checked its development and spread. Under favorable weather conditions there would have been a very severe epidemic, since the rust started earlier than usual and was universally present. However, the hot weather not only checked the development and spread of the rust, but ripened the wheat prematurely so that the damage caused by rust was not as serious as that caused by heat. It is almost impossible to estimate the relative amount of damage done by the rust and by the heat. (Department of Plant Pathology).

North Dakota: *Puccinia graminis* has again wrought great damage in the Red River Valley district of North Dakota and western Minnesota. It at first started in a spotted irregular manner indicating perhaps that our campaign for the eradication of the common barberry has had good effect locally. The first infections came on earlier than in previous years. The second infection came along normally, but what I call the general or final infection it seems did not get into full action. This was probably prevented by the intense drought and hot weather, otherwise, we should have had a very thorough repetition of the destruction by rust as shown in 1916. (Bolley).

Montana: Prevalent in northeastern Montana again this year for the first time since 1916. Distribution appears to be limited to following counties: Richland, Roosevelt, Sheridan, Valley, Phillips, Blaine (eastern part), Dawson (northern part), McCone (northern part). Infection varies from about 10% to 50%, becoming less to west and south in affected area. (H. M. Jennison).
None found in winter wheat crop. (Jennison).

Colorado: Very prevalent over the state in both the irrigated and dry land sections, but it came too late in the season to cause much damage. On the 24th and 25th of June, I found it in but two fields in a 160-mile drive, while on July 11 I made a one day trip covering much the same territory as on previous trip and it was from just present to 75% infection in every field inspected. This trip was made throughout both irrigated and dry land farming sections. It was very prevalent on the station farm and the variety plots, but it was much worse on the club wheats than other varieties. (Learn).
(June 30) - Nearly all fields examined showed leaf rust but little stem rust. Reports have been coming in from Weld and Logan Counties that about 50% of the wheat is being lost from stem rust. Our field men reported that leaf rust was heavy in these sections

but no stem rust. During July the pathology department of the college will survey these districts to determine whether leaf rust or stem rust is present.

(July 30) - Baca, Cheyenne, Kit Carson, Lincoln, Morgan, and Kiowa Counties) Black stem rust is quite widely distributed throughout this country on the spring wheat. The winter wheat matured early enough to avoid the rust, which seemed to enter the state from the east and southeast. Close observation of the stem rust situation showed that the spread was from the eastern border, where it was first noticed about June 10. Field observation taken along the foot-hill section west of Denver July 29 showed very little stem rust in either the winter or spring wheat. (John R. Fitzsimmons. Cereal Courier 13: 159-160. Aug. 10, 1921.)

Idaho: Much more prevalent than usual in all parts of the state. Appreciable damage resulting in some irrigated sections of south Idaho. (Hungerford).

Barberry infection.

One of the outstanding features of the development of stem rust during 1921 was the fact that barberries became very heavily infected early in the season (see Table 25 for dates of first appearance). A plant of Berberis trifoliolata became heavily infected at San Antonio, Texas as early as March 12. This bush had been inoculated with teliospores which had been formed at Boerne, Texas, but which had been kept at St. Paul, Minnesota during the summer and fall. The earliest record of natural infection of barberries was made by Fromme at Blacksburg, Virginia, where pycnia were found on native Berberis canadensis on March 29. Barringer found rusted barberries in Ohio April 16 and within a week infected bushes were found in several states. In Minnesota many bushes already were rusted on April 25. By May 15 barberries were quite generally rusted in the upper half of the Mississippi Valley and they were found infected as far north as Winnipeg, Manitoba, as early as May 23. In Colorado and Wyoming, on account of the high altitudes, barberry bushes did not begin to rust until late in May. The freeze which occurred in some of the Lake States killed many of the infected leaves on barberries but the new leaves soon became infected also. By the end of May rust already had spread to grasses and grains from the rusted barberries in many places.

Development of rust in the South

Rust did not develop especially early in the South (Table 25). Conditions had been favorable for rust development in parts of Texas during much of the winter. This is pointed out clearly by Prof. Wallace Butler, who inoculated wheat, growing in small plats in San Antonio, on January 21. By February 5 uredinia had appeared and by March 15 the plants were heavily rusted. But uredinia were not found in fields of oats near San Antonio until April 19 and on May 12 there was only a slight trace near Dallas, where there was also a trace on wheat. It seems quite likely, therefore, that there was insufficient inoculum to enable the rust to develop early.

The rust apparently did not develop in northern Kansas or southern Nebraska until about June 10. By June 15 there was a fairly general sprinkling of rust almost throughout the Lake states and in much of the hard red spring wheat region.

Table 25. Dates of first appearance of stem rust, 1921.

Aecia on Barberry				Uredinia			
Date	Place	Observer	Date	Place	Host	Observer	
Mar. 12	San Antonio, Tex (1)	Butler					
Mar. 29	Blacksburg, Va. (2)	Fromme					
Apr. 16	Greenville, Ohio	Barringer				Christopher & Butler	
" 18	Xenia, Ohio	"	Apr. 19	San Antonio, Tex.	Oats - 1-2%	Butler	
" 25	Heron Lake, Minn.	Melander	" 21	Boerne, Tex.	" t		
" 26	Blair, Nebr.	Thiel					
" 30	Corvallis, Ore.	Hoerner					
May 2	Ithaca, N. Y.	Kirby					
" 3	Rock Co., Visc.	Thompson & Clark					
" 3	Woodstock, Ill.	Schulz					
" 3	Harrison Co., Iowa	Carmichael					
" 7	St. Joseph Co. Mich.	Klotz					
" 10	Brookings, S. Dak.	Gilbert & Hutton	May 12	Dallas, Tex.	Wheat - t	Stakman & Christopher	
" 16	Tippecanoe Co., Ind.	Hosmer		" "	Oats - t	" "	
" 23	Winnipeg, Manitoba	Bisby	" 19	Salttillo, Mex.	Wheat, oats, barley (3)	" "	
June 1	Fort Collins, Colo.	Fitzsimmons	" 27	Denton, Tex.	" "	Christopher	
" 1	Chcyenne, Wyo.	Cotter	" 28	Durant, Oklahoma	Oats(h), wheat(t)	" "	
" 8	Dunn Center, N. Dak.	Mayoue	" 28	Copas, Minn.	Agropyron repens (4)	Christensen	
" 9	Beaver Creek, Mass.	Jean MacInnes	" 30	Trempealeau, Wis.	Oats, wheat (4)	Thompson	
" 9	Concordia, Kans.	Curran	" 31	Ardmore, Okla.	Wheat, oats	" "	
			June 1	Knoxville, Tenn.	Wheat	Mains	
			June 3	Lawton, Okla.	Wheat, barley, oats	Christopher	
			" 3	Black Earth, Wis.	Oats, wheat, quack	" "	
			" 4	Preble Co., Ohio	grass, red top (4)	Thompson	
			" 4	Marysville, Kans.	Wheat - winter (t)	Barringer	
			" 5	Hastings, Nebr.	Wheat, oats, rye	Thiel	
			" 6	New Ulm, Minn.	" "	" "	
			" 7	Ames, Iowa (5)	Wheat - winter (t)	Ostrom & Hinckley	
			" 10	Vevay, Ind.	Wheat	Melhus	
			" 13	Chatham, Mich.	Oats (h)	Jackson	
			" 13	Fargo, N. Dak.	Wheat - winter (t)	Kotila	
			" 13	Lincoln, Nebr.	Wheat - spring (t)	Weniger	
			" 14	Montgomery Co., O.	Wheat, rye, oats (1)	Thiel	
			" 14	Miami Co., Ohio	Wheat (h) (6)	Barringer	
			" 15	Bellefonte, Pa.	" (m)	" "	
			" 15	Bellefonte, Pa.	Wheat - winter (t)	Henry	

(1) *Berberis trifoliolata* inoculated with telia developed at Boerne, Tex., and kept in North until fall; (2) *Pycnia* on native *B. canadensis*; (3) Infection probably had occurred at least a month earlier; (4) Near rusted barberry; (5) At several other places also; (6) Extremely heavy infection on wheat, telial stage, result of the spread of rust from barberries near West Carrollton, Ohio, Montgomery County. Scattered light infection several places within radius of twenty miles from Dayton. All stem rust noticed attributed to barberry. (Barringer); (7) t=trace of rust - l=light infection - m=moderate infection - h=heavy infection.

At that time the rust was still rather light in Kansas and in Nebraska. Urediniospores of Puccinia graminis as well as spores of many other fungi are common in the air at elevations up to 10,000 feet above the surface. While the work upon which these conclusions are based (4) was not extensive enough to make it possible to make any definite statement regarding the movement of rust from south to north, it is quite possible that rust spores can be carried great distances by the wind. This would apply to urediniospores developed in the south as well as to those developed near barberries in the north. Just how long these spores retain their viability in the air is not known.

It is significant that barberries rusted in the north as early or even earlier than the uredinial stage of the rust developed commonly in the extreme south. Table 25 lists the dates when stem rust was first observed on barberries, cereals, or grasses. The first infections on common barberry were found about April 15. Observations made at Saltillo, Coahuila, Mexico, indicate that the uredinial stage of rust probably had begun to develop there at about the same time.

Relation of weather conditions to stem rust development

The weather apparently was quite favorable for the early development and rapid spread of rust in most regions early in the season, but later it became quite unfavorable. Temperatures were above normal almost throughout the country during March, and the total precipitation in the Mississippi and Ohio Valleys was greater than normal. The same thing was true in many regions in April. The abnormally high temperatures and the heavy precipitation probably accounted for the early appearance and the general prevalence of the rust on barberry. During May the weather was in general warm, although there was a cold wave over part of the upper Mississippi Valley about the middle of the month. The temperatures in June were for the most part far above normal, although there was a very wide range. The precipitation in the spring wheat region was somewhat below normal, but most of the rain occurred during the first half of the month, when there were many showers. Furthermore, hot days often immediately followed fairly heavy showers, and, in some regions, there actually was an excess of precipitation. The range in temperature, together with high temperatures accompanied by rain, probably accounts for the rapid development of the uredinial stage of the rust during the second decade of June. During the latter part of the month the temperatures in general were excessively high and there was but little precipitation with a great deal of sunshine. These conditions enabled the rust to develop rather rapidly. The excess of temperature over normal in South Dakota was 6.9° , in Minnesota 6.2° , and in North Dakota 5.4° . The precipitation was higher than normal in Colorado, Wyoming, Missouri, Kansas, New Mexico, Arkansas, Oklahoma, Texas, and Louisiana. By the end of June all the grain in the hard winter wheat region already had been cut. Consequently, the weather conditions for the first part of the month only were important as affecting the amount of rust in that region. The month of July was hot and in general it was rather dry, although there were excessive rains in some localities. Since spring wheat usually is not cut until about August 1, July weather is very important in determining the development of rust. In the Lake States the temperature was on the average 6° above normal, while in Minnesota it was 5.1° above normal. In some of the districts of the spring wheat region the rainfall also was excessive. At La Moure, North Dakota for instance, there were ten inches of rain, and in South Dakota not only was the heat excessive but the precipitation was above normal in the

northeastern counties. However, the effect of the weather in general was to ripen the grain prematurely and thus prevent the greatest amount of rust damage. The crop was harvested from two to three weeks earlier than it normally is and it is rather difficult, therefore, to determine just how much damage rust did and how much the hot weather did. In general, however, it would seem that the weather was extremely favorable for the development of rust until the latter part of June, after which it became unfavorable for the development both of rust and of wheat, except in those localities in which the heat was accompanied by high precipitation.

Progress in barberry eradication

The following summary on the progress of the barberry eradication campaign, by F. E. Kempton, Pathologist in Charge of Barberry Eradication, Office of Cereal Investigations, is especially interesting:

"The cooperative campaign for barberry eradication conducted by the U. S. Office of Cereal Investigations in Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming has advanced through its fourth field season.

"During 1918, an organization was formed, a wide-spread campaign of publicity and education conducted, and surveys to locate bushes were begun.

"In 1919, the city and village surveys were almost completed and a systematic farm-to-farm survey completed in about 90 counties.

"In 1920, a re-survey of cities and villages was conducted and the farm-to-farm survey completed in 88 more counties.

"In 1921, farm-to-farm survey, with re-survey of included cities and villages was completed in 142 counties. Of those, 23 counties in Minnesota were surveyed on funds furnished by the state and 165,662 bushes were found on 5,053 properties and 199,647 bushes were removed from 6,317 properties. Investigations were begun on chemical methods of eradicating both mature bushes and seedlings. See Table 26 for the year's results.

"From April 1, 1918 to October 31, 1921, all states in the eradication area provided themselves with laws compelling barberry eradication; almost all cities, towns, and villages therein were surveyed; and an area of approximately 321 counties was covered in the farm-to-farm survey with necessary re-surveys in a portion of these counties. The original survey is completed in Montana, Colorado, and Wyoming. A total of 5,619,971 bushes was located on 49,926 properties. Of those, 4,443,926 bushes were removed from 45,584 properties. These results include 10,000 bushes found and removed from 20 properties in cities and towns in North Dakota in 1917 which have not been included in previous reports. Of the 1,176,145 bushes remaining on 4,342 properties, about 1,000,000 are escaped bushes, most of which are under 18

inches in height on 3 large escaped areas in Wisconsin.
See table 27 for the results of the entire campaign."

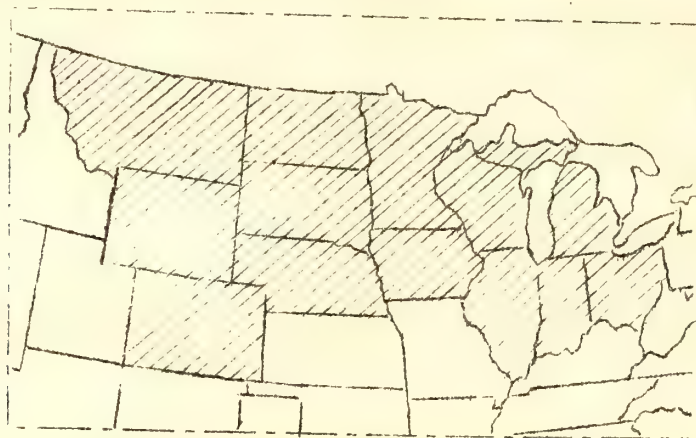


Fig. 41. Barberry eradication area (shaded portions).

Table 26. Data showing results obtained (number of bushes found and removed) in the barberry eradication campaign from January 1 to December 31, 1921.

State	Number of bushes						Sprouts found and removed re-survey
	In	In country		In both cities and		country	
	cities	Escaped	Total	Found	Removed		
	and towns						
Colorado	607	14	299	906	1,212	630	
Illinois	12,835	23,434	33,203	46,038	31,030	1,675	
Indiana	263	1,732	2,312	2,575	2,424	608	
Iowa	54	2,943	7,073	7,127	11,937	3,619	
Michigan	3,409	18,217	28,220	31,629	27,602	144	
Minnesota	630	2,641	7,143	7,773	8,022	5,265	
Nebraska	296	2,384	6,281	6,577	14,741	1,951	
North Dakota	298	150	1,925	2,223	2,223	276	
Ohio	3,360	4,565	5,645	9,005	25,475	2,281	
South Dakota	299	5,168	9,550	9,849	8,803	655	
Wisconsin	1,201	39,411	40,719	41,920	65,628	4,802	
Wyoming	14	0	26	40	550	50	
Total	23,266	100,659	142,396	165,662	199,647	21,956	

Valleau states that in experiments at Lexington, Kentucky, Ashland (a selection from New Jersey Fultz) proved practically immune from stem rust, while other strains of the same variety were severely attacked. Every field of Marquis wheat examined by scouts of the barberry eradication campaign in Griggs, Foster, and Eddy Counties in North Dakota was badly damaged by stem rust, the reduction in yield ranging from 10-40%, while in the same area reduction in yield of durum wheats was about 5%, according to George C. Mayoue (Cereal Courier 13: 201. Sept. 10).

Table 27. Data showing results obtained (number of bushes found and removed) in the barberry eradication campaign from April 1, 1913 to December 31 1921.

State	Number of bushes					
	In	In country	In both cities and	Sprouts		
	cities	Escaped	country	found and		
	and	Total	Found	Removed	the re-survey	
	towns					
Colorado	19,172:	1,411:	3,376:	22,548:	22,457:	3,226
Illinois	92,500:	25,635:	42,289:	134,789:	114,897:	2,336
Indiana	75,288:	4,173:	12,446:	87,734:	86,342:	2,460
Iowa	642,544:	32,216:	89,196:	731,740:	731,545:	6,502
Michigan	39,360:	76,960:	131,916:	171,276:	119,878:	189
Minnesota	588,734:	53,509:	152,574:	741,308:	741,087:	15,427
Montana	6,577:	1:	2,105:	8,682:	8,671:	4,515
Nebraska	71,296:	3,185:	12,338:	83,634:	82,934:	3,276
North Dakota*	14,080:	150:	3,035:	17,115:	17,115:	491
Ohio	197,120:	19,774:	25,747:	222,867:	199,367:	2,281
South Dakota	22,223:	14,407:	23,812:	46,035:	38,908:	1,568
Wisconsin	276,573:	3,063,763:	3,071,430:	3,348,103:	2,279,583:	13,086
Wyoming	3,946:	1:	194:	4,140:	1,042:	240
Total	2,049,513:	3,295,185:	3,570,458:	5,619,971:	4,443,826:	55,597

*The results for North Dakota include 10,000 bushes found and removed from 20 properties in cities and towns in 1917 which have not been included in previous reports.

Varietal susceptibility

Data concerning susceptibility of wheat varieties to stem rust are summarized in Table 28.

Table 28. Varieties reported as susceptible or resistant to stem rust of wheat, 1921.

Resistant	Susceptible
Ashland (a selection of Jersey Fultz), Kentucky	Other strains of Jersey Fultz, Kentucky
Kanred, Michigan	Fulcaster, Tennessee
Durum wheats, North Dakota	Marquis, North Dakota
	Kharkof, South Dakota
	Club wheats, Colorado
	Hard Federation, California
	White Federation, California

Experiments conducted at the Kansas (2), Minnesota (1,3), and North Dakota (4) stations with a view to producing resistant hybrid varieties have shown promising results.

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Leaf rust caused by Puccinia triticina Eriks.

Leaf rust of wheat was much more prevalent and destructive in 1921 than in 1920. In fact, it probably was more severe than it has been for several

Importance of leaf rust in 1921

t=Trace, loss negligible
 +=More than in 1920
 -=Less " "
 *=Prevalent, no appreciable damage or not distinguishable
 0=Not reported to collaborator

Fig. 42. Occurrence of leaf rust of wheat in the United States and estimated reduction in yield in 1921.

Just how much of the reduction in yield is attributable to the rust and how much to the hot weather and drought, cannot be stated definitely. The situation may be somewhat similar to that with respect to the stem rust. Unfortunately, whenever rust is very destructive weather conditions also are likely to be unfavorable for the best development of the crop, consequently, it is difficult to evaluate the factors accurately. However, there seems to be a general unanimity of opinion that this year the leaf rust did a considerable amount of damage in much of the soft-red winter wheat area; in New York, Pennsylvania, Maryland, Delaware, Virginia, North Carolina, Tennessee, Kentucky, Ohio, Indiana, Arkansas, part of Oklahoma and Missouri, and eastern Kansas. The map (Fig. 42) gives estimated losses from leaf rust in 1921.

The area in which leaf rust is most destructive does not coincide with that in which stem rust does the greatest damage. By referring to the stem rust map (Fig. 40), it will be seen that the greatest damage was done by the disease in Ohio, Michigan, Wisconsin, Minnesota, the two Dakotas, Northeastern Montana, and California. However, it is exactly in these states in which the leaf rust was of minor importance, with the exception of South Dakota and Ohio, in which the leaf rust is estimated to have caused a reduction of about 5% in yield while the stem rust caused a reduction of 6% in Ohio and 10% in South Dakota. However, while the reduction in yield in Michigan, Wisconsin, Minnesota, and the Dakotas, due to stem rust, was from 5% to 20%, the reduction in yield in these states due to the attacks of leaf rust was almost negligible. This cannot be explained on the basis of date of appearance of rust. Leaf rust was found on winter wheat in Minnesota as early as May 2, and no stem rust had appeared at that date except in the aestival stage on barberries. It seems quite likely that the true reason for the comparatively insignificant damage from leaf rust in the hard red spring wheat area is that many of the hard red spring wheats and durum wheats are quite resistant to leaf rust. Marquis, for instance, the most commonly grown bread wheat in the hard red spring wheat region, rusts only about half as much, on the average, as the most susceptible winter wheat varieties. The uredinial stage of the leaf rust overwinters commonly in the hard red spring wheat region, as it does in practically all other parts of the United States. The mild winter and the early spring this year enabled the rust to start early and to develop epidemic proportions before harvest time. Some of the hard red winter wheats of the Crimean group also are quite resistant to leaf rust, and therefore usually are not severely injured. Most of the soft red winter wheats, on the other hand, are quite susceptible and the greatest damage in general seems to occur in the region in which they are grown. The situation in California is rather interesting. Stem rust, which is known to overwinter in certain districts, caused a reduction in yield of 15%, while leaf rust which overwinters much more readily and under more unfavorable conditions than does the stem rust, caused a reduction in yield of only 2%. Possibly varietal susceptibility also may account for this fact. It seems to be true that the leaf rust is much more infectious than the stem rust: it apparently can develop under a wider variety of conditions and thus spreads more rapidly. It is quite likely, therefore, that varietal susceptibility is the determining factor in its distribution.

A few of the early dates of appearance of leaf rust are given:

Brownsville, Texas, Jan. 3	Wichita, Kansas, April 6
Johnson County, Kansas, March 2	Pawnee & Perry, Okla., Apr. 8
Dewitt, Nebraska, April 4	Dallas, Texas, Trace to 100%
Knoxville, Tennessee, April 4	April 9.

The following comments on the occurrence and destructiveness of leaf rust are particularly interesting:

New York: The leaf rust of wheat was especially severe in 1921. The epidemic of leaf rust seems to have been caused by a very mild 1920-21 winter and the exceptionally early spring which allowed this rust to get a very early start. It seems very likely that leaf rust may have caused at least 5% loss to the New York wheat crop. (Kirby).

Delaware: First reported this season April 8. Considerable infection was found on young plants as late as December, last year. Has been very severe this season. Fields appeared prematurely ripening as result of severe leaf infection. Infection on glumes common and many fruits found with sori at the crown. (Manns).

Virginia: More epidemic than I have ever observed it before. Especially severe on early sown wheat. This injury combined with that caused by late frosts probably caused greater reduction in yield than any other single agency. (Fromme).

West Virginia: Leaf rust seemed to have done the most damage this season, perhaps due to the unusually mild winter. This trouble was considerably aggravated by a dry spell that followed after the wheat headed. (Berg).

Tennessee: Leaf rust showed its appearance this year much earlier than usual. During the first week of April in the earliest and best wheat fields around Columbia, the infection was from 50-80%, and in May and June the infection in most of the fields ranged from 60-100%, averaging probably about 90%. The actual damage caused by the rust is very hard to estimate and may be guessed at about 10%, ranging from very light, in the case of late fields and somewhat rust-resistant wheat varieties, to probably close to 40% in the case of the earliest fields and with the susceptible varieties. (Sherbakoff).

North Carolina: In Buncombe County I covered a large area. The general opinion of the growers and county agents was that the wheat crop this year was the poorest they had seen in years, due partly to unfavorable weather conditions but mostly to the damage done by the leaf rust and Hessian fly. The two most common and universal diseases found in this county were leaf rust and Septoria.

.....The wheat crop was very poor in Wilkes County, due to the unfavorable weather, the fly, and the rust.

In the other counties visited, - namely Surry, Alexander, Yadkin, Forsyth, Rockingham, Guilford, and Durham - the wheat was very poor also. The only diseases commonly found were the rust and Septoria. (Foster).

Oklahoma: Crop sown late has less rust and bids fair to outyield the early sown. Rapid deterioration noted in crop generally on account of orange leaf rust and dry soil. (Bu. Crop Est. Crop Notes, week ending May 14.)

The rusts have been very bad this year, especially the orange leaf rust, practically all fields of wheat being badly infected with it, usually 40-65% according to the chart. Kanred and Black Hull Turkey varieties showed usually about 10%, showing much resistance to the rust. (Stratton).

Kanred and black Hull Turkey least susceptible. (Stratton).

Ohio: The attack has been very severe and in many fields seemed to be responsible for the premature ripening. It is very difficult, however, to estimate damage from this disease. (Clayton).

The attack has been very severe and the farmers feel that it has cut the yield more than any other one thing in many cases. Certain it is that in those areas worst affected they are only threshing out from three to ten bushels of wheat to the acre. Extreme southern Ohio was worst affected. (Clayton).

Indiana: Leaf rust has been very severe, more so I think than in any year since I have been in Indiana. It is practically universally present, so much so as to be commented on in the papers, and has attracted a good deal of attention. Opinions differ as to the loss and it is of course very difficult to get at anything tangible in this connection. I am convinced, however, that there has been considerable loss from the leaf rust this year, particularly where the infection occurred early. (Jackson).

Illinois: The men engaged on flag smut survey in the bottom lands of the Mississippi River during May and June found leaf rust very abundant and, according to growers, it was much more serious than usual. In many fields the wheat kernels were slightly shriveled and the heads were not entirely filled. Leaf rust may have been partially but probably not wholly responsible for this condition. (Haskell).

Universally distributed where spring wheat was grown in Illinois. It ran as high as from 25 to 40%, according to the U.S.D.A. scale for estimating rust. (Dungan).

Wisconsin: Widespread. Destructiveness questionable. (Vaughan).

Minnesota: First report May 6 in Ramsey County. The leaf rust on wheat came early this year and was much more prevalent than it usually is. The degree of infection ranged from trace to 100%. As far as has been determined, no damage was done. This likely is partly due to the fact that most of our spring wheat varieties are moderately resistant to the disease. Furthermore, the hot weather checked the development of the rust and probably prevented it from doing appreciable damage. (Department of Plant Pathology).

Missouri: Mr. Curran of the rust survey of the Office of Cereal Investigations, examined the wheat and oats on the Station field today. A small amount of leaf rust was found on most of the varieties of wheat and rye but no stem rust was detected. (L. J. Stadler, Columbia. Cereal Courier 13: 72. May 10.)

North Dakota: Leaf rust has been generally and rather evenly distributed throughout the state, starting early in the spring, and in many cases caused a large amount of defoliation, particularly on some varieties which are otherwise quite resistant to stem rust. (Bolley).

The first appearance of Puccinia triticina was observed on May 27 on Kota and Acme wheats. (W. E. Brentzel. Cereal Courier 13: 103. June 10.)

South Dakota: Leaf rust is very abundant. In many cases it is doing serious injury to the grain, I feel sure. On many of our plots every leaf is dead yet the grain seems to be filling rather well. I can't conceive, however, of its filling entirely without shriveling under these conditions. (Evans).

Very severe. Some fields a few per cent, many fields 100%. Must have done some damage although I found no shriveling directly traceable to it. (Evans).

Kansas: Soft wheat has been injured to some extent by red leaf rust in eastern Kansas.

Field inspection of Kanred wheat has been completed except for some fields of Kanred in extreme northwestern counties which will be inspected the last week in June. Kanred is again manifesting a remarkable degree of resistance to leaf rust in all sections of the state. (John H. Parker. Cereal Courier 13: 125. July 10.)

Montana: Significant damage in certain localities; never so common before. (Jennison).

More or less common throughout the state where spring wheat crop amounts to anything. In more moist districts considerable amounts of winter wheat leaf tissue killed. (Jennison).

Colorado: Practically over the entire wheat section. More common on dry land than irrigated. (Learn).

Washington: Present in severe form in some fields especially on some of the club hybrids. (Heald).

Oregon: General; more than usual or than last year; reduction a trace. Found in 90% of the fields in the state. In the Willamette Valley as many as 100% of the plants heavily affected in some fields. First noticed May 28 at Melrose. (Barss).

California: Puccinia triticina was very abundant in nearly all wheat fields but was more pronounced in the Sacramento Valley and Delta regions where damage resulted, especially in spots of lodged grain. (Mackie).

Both Hard and White Federation are susceptible to the common leaf (triticina) rust. (V. H. Florell, Cereal Courier 13: 106. June 10.)

Mexico: Fairly prevalent but not destructive. (Stakman & Christopher).

Varietal resistance

The following summary of varietal resistance was supplied by Dr. E. B. Mains:

"In general the most resistant of the bread wheats are the hard winter varieties of the Crimean type. Certain strains of Malakof, Hungarian, Banat, Budapest, Kharkof, Beloglina, Crimean, Turkey, Eversole, Kanred, Kansas P 1066, and Kansas P 1068 have shown high resistance in one or more of the plantings mentioned above, the last three of these varieties being highly resistant in all. These wheats, of course, are not well adapted to eastern conditions and although we do not have so many varieties among the softer winter wheats showing as high a resistance as the above, yet certain strains of Mediterranean, Red Hussar, and Imperial Amber are giving considerable promise, showing up especially resistant at Arlington this past season. Our work would indicate that a number of other strains of soft winter varieties, while not highly resistant, still are only moderately susceptible. Those showing the most promise are certain strains of Fulcaster, Fultz, Currell, Michigan Amber, Red Cross, Pennsylvania 44, and Blue Ridge. The spring wheat varieties, Haynes Bluestem, Preston and Marquis in general show this moderate susceptibility.

"Among the wheat species the Emmers are usually more or less resistant, especially Khapli and Black Winter. The Spelts are also rather highly resistant, especially Alstrom, Red Winter and White Winter. In a similar way the Durums usually show considerable resistance, especially Acme, Arnautka, D5, Goose, Mindum and Monad. The one strain of Rivet and Emmer tested were both highly resistant. The Club wheats, so far as we have tested them, are all extremely susceptible with the exception of a little grown variety known as Binkel Club, which has shown moderate susceptibility.

"This covers in a general way the situation for the eastern part of the country. The presence of three or four strains in this region, of course, complicates the situation. Further study will doubtless be necessary in order to definitely establish whether these varieties will maintain their value, but I think there is no question but what the disease can be considerably decreased by a number of the more promising and that still more highly resistant varieties can be obtained by hybridizing."

Recent literature

Jackson, H. S., and E. B. Mains. Aecial stage of the orange leaf rust of wheat, Puccinia triticina Eriks. Jour. Agr. Res. 22: 151-172. Pl. 21. Oct. 15, 1921.

Stripe rust caused by Puccinia glumarum (Schm.) Eriks. & Henn.

During the past year stripe rust was found only in Montana, Idaho, Washington, Oregon, and California. None was found in South Dakota, where it

was found on barley several years ago. Dr. Arthur W. Evans made a very careful search for stripe rust during the past season but was unable to find any trace of it. Therefore, it is evident that the disease is not spreading eastward very rapidly. The real reason for the failure of the rust to spread eastward would furnish the subject for some interesting experiments.

In the region in which the yellow stripe rust occurred in 1921, it did but little damage. Jennison reports that it was very common on Craik Fife in irrigated sections of Montana, that it was particularly prevalent where the ground was low, and that it did some damage by killing leaf tissues. However, he states that the damage for the state was negligible. Hungerford reports that stripe rust was more prevalent in Idaho than it has been since 1915. It seems to be most common in the northern part of the state, in which scarcely a wheat field is free from the rust. However, Hungerford states also that the damage was very slight. Heald reports that the rust occurred in Washington but that there was only a small amount and apparently no appreciable damage was done. In Oregon, according to Barss, the disease was more prevalent than usual but unimportant. Jenkins Club and Forty-fold were the varieties most severely affected in the fields surveyed in the state. D. E. Stephens reports as follows in the Cereal Courier 13: 186. June 10, 1921.

"A little stripe rust is present (at Moro, Oregon) on some of the winter wheats, one of the Forty-fold x Federation hybrids in the nursery having an especially heavy infection. Adjacent rows of cross between Turkey and Karun show no infection yet."

V. H. Florell (California) contributed the following (Cereal Courier 13: 106. June 10.):

"The White Federation was found to be a particularly congenial host to the yellow stripe (glumarum) rust. Stripe rust was observed on this variety at all points except two where the drought was most severe. Stripe rust is rarely found on Hard Federation."

Dr. H. B. Humphrey states that the rust was very prevalent in the experimental plots at Corvallis, Oregon, and that some varieties were affected severely. He states also that it was quite abundant in the Puget Sound region of Washington. In general, however, the rust seemed to be of very minor importance in 1921.

A manuscript summarizing the knowledge concerning the occurrence of the disease in the United States is now in process of preparation by Dr. Humphrey and others.

Reference:

Armstrong, S. F. The Mendelian inheritance of susceptibility and resistance to yellow rust in wheat. Jour. Agr. Sci. 12: 57-96. Feb. 1922.

Scab caused by Gibberella saubinetii (Mont.) Sacc.

Wheat scab (Fig. 43) apparently caused even less damage in most states in 1921 than it did in 1920, and certainly a great deal less than in 1919. The

disease was not found at all in the New England states nor in the Gulf states. Neither was it found in Texas, Oklahoma, Montana, Idaho, Washington, or Arizona. Only a single diseased specimen, according to Learn, was found in Colorado. Reports of collaborators indicate that the disease was unimportant in all states except those which are listed with percentage reduction in yield as follows: Ohio 7%, Illinois 4%, Missouri (considerable), Maryland 2%, West Virginia 2%, and North Dakota 5%. The only appreciable damage occurred in part of the soft red wheat region. The figures on losses refer almost entirely to head blight. Very little differentiation is made in collaborators' reports between the seedling blight caused by the scab organism, and seedling blights caused by other fungi. Consequently, accurate estimates of losses due to the seedling blight caused by the scab organism are not possible.

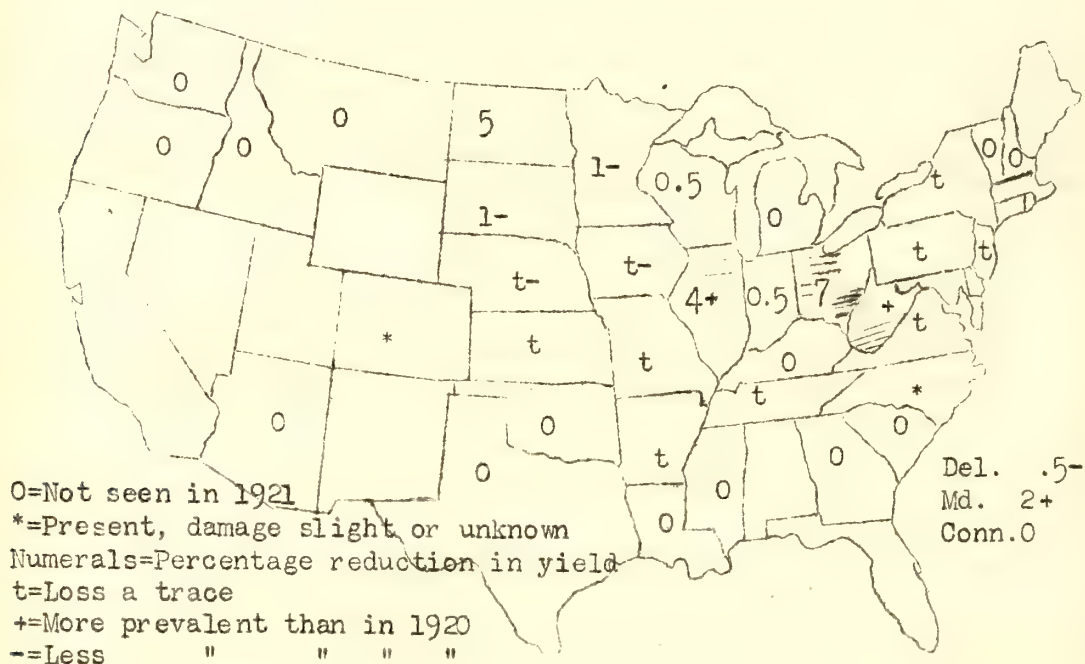


Fig. 43. Estimated percentage loss from wheat scab in 1921.

Relation of weather conditions to the development of scab

Weather conditions, as a rule, were unfavorable for the development of scab. Comments on this point are made by collaborators in Indiana, Kentucky, Tennessee, Virginia, South Dakota, and Minnesota. In all of these states the weather was rather hot and dry during the flowering period of the wheat. Consequently, very little infection occurred. In Ohio, however, and in some of the other states in the Ohio River Valley, weather conditions were very favorable for the development of scab in some localities and special attention is called by collaborators to the local occurrence of the disease. In most cases this can be correlated with the weather conditions at flowering time. In some states, in which both winter and spring wheats are grown, spring wheat was more severely injured than winter wheat. Both in New York and Illinois, Marquis wheat was much more severely injured by scab than were the winter varieties which are commonly grown.

The following comments made by collaborators in the various states give a fairly good idea of the scab situation in 1921:

New York: Fusarium scab seemed to be negligible factor in winter wheat as never more than a few infected heads were found in a single field. In spring wheat, where the growing region is farther north and Marquis is the principal variety, scab was found to be quite common. Scab was present to the extent of 5% in 175 acres of the fields of the biggest spring wheat seed salesman of the state. (Kirby, August 22).

Slight except for spring wheat which was reduced 5%. Damage largely in northern part of state. (Kirby).

Virginia: Occurred only in very slight amounts this year. There were practically no rains during blooming period. (Fromme).

Kentucky: Dry hot weather set in shortly before flowering period. No scab observed. (Valleau).

Tennessee: (Observations made during April, May, and June in the vicinity of Knoxville, Murfreesboro, Columbia, Nashville, Jackson, and Union City.) Wheat scab infection was extremely slight; in most of the fields only occasional specimens, and then not very conspicuous, could be found. No field was observed that was affected with the disease to any serious extent. Extremely dry weather during the time of blooming and during maturity of the wheat is the probable explanation of the low infection with the scab. (Sherbakoff).

Louisiana: Have never seen it in state. (Edgerton).

Arkansas: Scab has never been of importance here. (Elliott).

Ohio: The counties of Coshocton, Muskingum, Ross, Pickaway, Darke, and Van Wert were visited.

I was somewhat surprised to find disease conditions so serious in Ross County. Wheat fields in the overflow lands of the valleys were all badly infected with wheat scab. In some cases infection was 15%. It was interesting also to note that in general throughout Ross County the rotation corn, wheat and clover was quite universally followed.

The same general situation prevailed in southern Pickaway, such as I had opportunity to investigate.

Farther north in Van Wert County scab is very much less noticeable.

I am quite positive that wherever I investigated fields where a longer rotation is employed, - namely, corn, oats, wheat, and clover, or corn, oats, tobacco, wheat, and clover, also where some other legume such as alfalfa, soybeans, or sweet clover is introduced into the rotation - scab infections were very much lower. I was especially interested in the rotation investigations, not only as regards scab of wheat, but also in connection with the clover root rot disease which we have at the present time under investigation. (R. C. Thomas, June 27).

During the forepart of the season scab was very little in evidence. About June 15 this trouble became epidemic in Ohio, however, and since then has caused heavy loss with certain varieties. Of the pedigreed wheats, counts in many fields have shown that the Portage is very subject to scab attack while Gladden and Trumbull are not.

In one case where three varieties were planted side by side in the same field the counts were:

Portage-----	12% scab
Ohio Pride-----	2% scab
Trumbull-----	1% scab

Fields of Portage with as many as 50% of the heads affected by scab have been reported, while the average for the state has been around 10%. Gladden under the same conditions has shown about 1.5 to 2% scab, and Trumbull about 1%. (Clayton).

Scab developed late and caused severe loss with only one variety so far as I have observed. The Portage wheat, an improved variety, distributed by the Experiment Station was very badly affected and fields of Portage with as high as 50% of the heads affected have been reported.

Most varieties showed 1 to 3% of the heads attacked by scab. (Clayton).

More than usual, and more than last year, with a reduction in yield for the state of 5 to 10%. The infection was general but was worst in southern part of state. Greatest injury occurred after blossoming period, when weather was favorable for the disease. (Thomas).

Indiana: Very much less than usual; probably same as in 1920. Attributed to weather conditions unfavorable to infection. Less than 1% loss. (Gardner).

Illinois: In northern Illinois scab on spring wheat was very severe; running as high as 30% on the average. In central Illinois it was as bad as 12%. Little or no spring wheat is grown in southern Illinois. (Percentage based on number of heads infected. (Dungan).

Wisconsin: For the state as a whole infection was generally light but in spots in the southern part of the state, where more rain occurred and where wheat followed corn, there was some damage. (A. G. Johnson).

North Dakota: Naturally, scab in wheat, wilt in flax, ergot and similar wind-born troubles are more destructive in the counties of intense cultivation and particularly in the eastern part of the state where the soil and moisture conditions are more favorable. (Bolley).

Varietal resistance

Since it is difficult to control scab by ordinary means, varietal resistance is extremely important. There are very sharp differences in the susceptibility of the different varieties to the scab. In the hard red spring wheat region, for instance, the durumms as a class and Marquis are extremely

susceptible, while Preston, Haynes bluestem, and several other varieties are much more resistant. Results of preliminary varietal tests at University Farm, St. Paul, Minnesota, have been furnished by Mr. J. J. Christensen, of the University of Minnesota (Table 29).

Table 29. Varietal susceptibility of wheat varieties to scab in 1921 in Minnesota, according to data furnished by J. J. Christensen.

Variety	:Percent heads blighted:		:Percent of seeds of infected heads blighted	
	A	B	A	B
Preston, Minn. 924	0	.5	0	3
Haynes Bluestem, Minn. 163	1.5	.5	9	4
Glydon Fife, Minn. 163	1.5	0	11	0
Kota C. I. 5878	1.5	3	8	9.8
Kitchener C. I. 2153	2.5	1.5	10.3	10.5
Ruby C. I. 2151	2.5	3	28	18
Prelude C. I. 4323	2.9	3.9	8.1	15
Red Bobs C. I. 6255	2.5	8.3	11	23
Red Durum C. I. 1446	3	11	12	12.1
Marquis C. I. 1239	4.5	9.5	19	18
Acme C. I. 1967	6.5	8.5	19	12.3
Kubanka C. I. 2102	8.8	7.9	27.7	10
Monad C. I. 2156	12	10	18	14.5
Mindun, Minn. 470	14.5	9	14.1	16.6
Kubanka C. I. 2094	19.5	14	13	18.8
Kubanka (8) C. I. 4063		25.4		11.4

1. (A) planted April 23

2. (B) " May 10

Recent literature

- Johnson, A. G. and J. G. Dickson. Wheat scab and its control. U. S. Dept. Agr. Farmers' Bul. 1224: 1-16. Illus. 1921.
- Rose, Jessie P. A seedling blight caused by Fusarium culmorum var. leteius Sher. (Abstract). Phytopath. 12: 28. Jan. 1922.
- Sherbakoff, C. D. Fusaria of wheat and corn. (Abstract). Phytopath. 12: 45. Jan. 1922.

Take-all caused by Ophiobolus cariceti (Berk. & Br.) Sacc.
(=Ophiobolus graminis Sacc.)

Take-all caused by Ophiobolus was reported for the first time in the United States by Kirby and Thomas in October 1920. Since that time it has been found also in Indiana, Arkansas, and Oregon. The following extracts from the summary of the survey for take-all and flag smut in 1921, prepared by R. J. Haskell, gives the available information regarding the occurrence of the disease:

"1. Take-all associated with Ophiobolus.

As a result of this season's work Ophiobolus has been found associated with foot rots in three new states. It was found again in New York, this year in great abundance, and

in addition was discovered in Arkansas, Indiana, and Oregon.

"The New York situation is a rather serious one.

Take-all has been found scattered through the major part of the western grain belt. It is present in at least nine of the sixteen counties surveyed and in many localities in considerable quantities. The disease is readily distinguished by the blackened bases of the culms accompanied by the mycelial plate and perithecia in most cases. It must have been present in the state for some years to have spread over so wide a territory.

"In Arkansas a disease having the same appearance as that in New York was found in two fields near Fayetteville by H. R. Rosen and in both fields an *Ophiobolus* was found on the diseased culms. In the first field the disease was generally prevalent throughout the whole eleven acres but was worse in spots; and in the second field, it was general but spotted in only three of the eleven acres, the three acres having been in peach orchard the year before.

"In Indiana, H. S. Jackson received specimens from Knox County having signs of take-all and an inspection of the locality showed three infested fields on a farm ten miles east of Vincennes. The disease was in spots of two to three feet in diameter. Immature *Ophiobolus* perithecia were found on the culms and from Jackson's description it appears to be like the New York disease.

"In Oregon, H. P. Barss found *Ophiobolus* near Hillsboro and in a number of other localities. At Hillsboro the loss in some cases is estimated at one-third the crop, the spots ranging up to 100 feet in diameter.

"2. Ophiobolus on wild grasses.

"*Agropyron repens* was found infected with *Ophiobolus* by R. S. Kirby in Genesee County, New York on June 10 and in the greenhouse Mr. Kirby appears to be getting infection on certain species of the genera *Bromus*, *Agropyron*, *Elymus*, and *Hordeum*. Johnson, Rosen, and McKinney collected *Festuca*, *Bromus*, and *Hordeum* in one of the infested fields in Arkansas on June 11 that seemed to be affected with the same disease as the wheat, and on June 23 Rosen reported he found perithecia, asci, and ascospores of *Ophiobolus* on *Setaria geniculata* growing on the campus at Fayetteville.

"Evidence pointing to the importance of grasses as hosts for *Ophiobolus* was found in the field in Arkansas where the disease occurred only in the three acres that had been in peach orchard in 1920. In the other Arkansas case the field had been in pasture for 12-14 years and the same seed planted on another part of the farm showed no disease.

"The occurrence of *Ophiobolus* on wild grasses will prevent control of take-all by rotation and will make the disease that much more difficult to combat."

Ophiobolus has apparently kept on doing considerable damage. Kirby reports that it is one of the most important cereal diseases in New York. It

kills the plants prematurely, and infected plants are not likely to produce more than 1% of a normal crop. The reduction in yield for the state of New York is estimated at approximately 1%. Barss reports as follows regarding the situation in Oregon:

"Wheat specimens received from E. B. Dunsmore, Mosier, Oregon, looked like typical *Ophiobolus*. Fifty acres affected. Ten acres entirely killed out. Twenty-six acres hardly worth harvesting. The ten-acre tract went forty tons wheat hay two years ago."

Less is known about the destructiveness of the disease in other regions. The map of New York and the map of Oregon (Figs. 44 and 45) show how widely distributed the disease is in those states. The pathogene occurs on various other hosts besides wheat. It is especially important to note that it has been



Fig. 45. Occurrence of wheat take-all in Oregon in 1921. (After map by H. P. Barss.)

found in nature on several grasses. Kirby found *Agropyron repens* infected in New York, and in Arkansas Rosen found the organism on *Setaria geniculata*, and also on a grass which appeared to be *Hordeum pusillum*. Kirby (1) states that he has been able to infect wheat, barley, rye, and one or more species of the following genera of wild grasses: *Agropyron*, *Bromus*, *Elymus*, *Festuca*, *Hordeum*, *Hystrix*, *Lolium*, and *Phalaris*. He says also that in New York Number 6 Junior wheat appeared to be slightly more susceptible than Dawson Golden Chaff and Red Rock. In Oregon, according to Barss, Forty-fold, Dawson Golden Chaff, and White Winter varieties were most severely affected, while Rink and Jenkins' Club were only slightly attacked. It

is quite possible, therefore, that the disease may be controlled by the use of resistant varieties. A general summary of what is known about the disease in New York has been made by Kirby.

Recent literature

Cited:

Kirby, R. S. The take-all disease of cereals and grasses. (Abstract). *Phytopath.* 12: 27. Jan. 1922.

Not cited:

Fitzpatrick, H. M., H. E. Thomas, and R. S. Kirby. *Ophiobolus cariceti* (Berk. & Br.) Sacc., cause take-all of wheat. (Abstract). *Phytopath.* 12: 27. Jan. 1922.

Fitzpatrick, H. M., H. E. Thomas, and R. S. Kirby. The *Ophiobolus* causing take-all of wheat. *Mycologia* 14: 30-37. Jan. 1922.

Foot and root rots of wheat

Several destructive foot and root rots of wheat have been reported during the past year. The etiology of some of these is not yet definitely determined, but they can be grouped for convenience under several heads: (1) rosette (so-called take-all), which has been under observation since 1919 in Illinois.

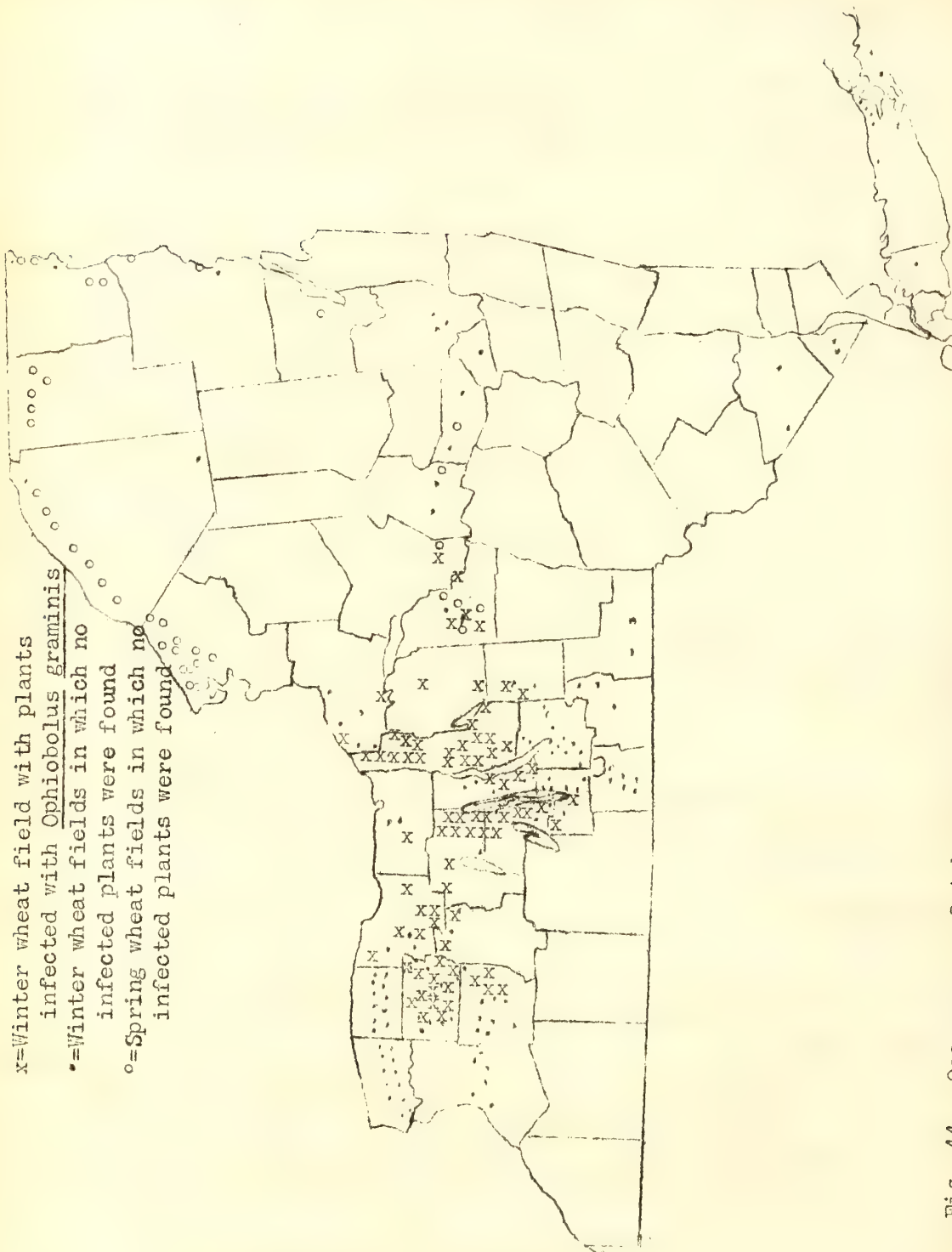


Fig. 44. Occurrence of take-all in New York, 1921 (after map prepared by R. S. Kirby). The disease is also known to occur in Indiana, Arkansas, and Oregon.

and which occurs also in Indiana; (2) the foot and root rot of wheat, barley, rye, and various grasses which is caused by Helminthosporium sativum and possibly other species of the genus. (For symptoms see Minn. Agr. Expt. Sta. Bul. 191); (3) foot rots of unknown causation, but with definite and characteristic symptoms; (4) foot and root rots of unknown causation and with indefinite symptoms.

Rosette, probably caused by Helminthosporium sp.

Rosette (so-called take-all) which was discovered in Illinois in 1919 is now well under control. The disease caused less damage in 1920 than it did in 1919 and in 1921 it caused still less damage. This probably is due to the fact that resistant varieties now are being grown in the infested regions. Dungan reports that there was only a trace of the disease in Madison and Logan Counties, Illinois, while the following excerpt from the report of Mr. J. R. Kendrick on conditions in Indiana, summarizes the situation in that state:

"On June 17, a trip was made through the take-all quarantined area in northern Indiana, to examine spring wheat, winter wheat, and to look up a reported root rot of rye.

"Sixty acres of spring wheat were examined, and no evidence of any root rot or take-all was found. The wheat is in good condition and is apparently better than the winter wheat. I believe the 60 acres comprise all the spring wheat in the quarantined region. The serious damage done by the Hessian fly in 1920 and the past scare due to the outbreak of take-all have made the farmers hesitate about sowing much wheat. They seeded a large acreage of rye last fall.

"Something like 150 acres of winter wheat were examined and no evidence indicating take-all was present could be found."

There are very sharp differences in varietal susceptibility to the rosette disease. The following summary, prepared by H. H. McKinney, is taken from the Cereal Courier 13: 186-188. August 31, 1921:

"During the present crop season 150 varieties and selections of wheat were grown on infested land to determine relative susceptibility to the so-called take-all disease. These experiments were conducted near Granite City, Ill., by the Office of Cereal Investigations, United States Department of Agriculture, in cooperation with the Illinois Agricultural Experiment Station. The susceptible varieties are shown in Table 30, and the more commonly grown ones that showed marked resistance are listed in the paragraph which follows. None of the latter showed any infection with the so-called take-all. These results, in general, agree with those obtained in 1920, particularly in that Harvest Queen (the white-chaffed Red Cross, locally known as Salzer's Prizetaker) was found to be highly susceptible,

and Red Wave, Early May, and a strain of Turkey highly resistant. Illini Chief was considerably more heavily infected in 1920 than in 1921."

Table 30. Percentage of disease on susceptible winter wheat varieties grown in infested soil to determine relative susceptibility to rosette at Granite City, Ill., 1921.

Variety	Seed Source	Percentage of Disease
Harvest Queen (Red Cross (white chaffed), Salzer's Prizetaker)	Illinois Station	95
Selection No. 13462 (bearded, red-chaffed)	C. I. No. 4834	95
Harvest Queen	C. I. No. 4882	75
Niagara (Sel. No. 13535)	C. I. No. 5307	70
Velvet Chaff (Penquite)	C. I. No. 3540	65
Missouri Bluestem	C. I. No. 1912	60
Dawson (Dawson's Golden Chaff)	Ill. 9-225	1-
" " " "	C. I. No. 6161	1-
Illini Chief	Illinois Station	1-
" "	C. I. No. 5406	Trace
Budapest	C. I. No. 5789	"
Turkey (Wis. No. 18)	Illinois Station	"
World's Champion	" "	"

The following varieties from the sources indicated showed no infection:

Beloglina, Illinois Station and C. I. No. 5964
 Crimean, C. I. No. 5831
 Currell, C. I. Nos. 2906, 3326, 4802
 Dietz Longberry, C. I. Nos. 1981 and 3387
 Early May (local)
 Fulcaster, C. I. Nos. 3013, 3407, 4862
 Fultz, C. I. Nos. 1923, 3349, 3423, 3594, 3598
 Gypsy, Illinois Station and Nos. 3439 and 3440
 Gladden, Illinois Station and 5644
 Gold Coin (Junior No. 6), C. I.
 Grandprize, C. I. No. 5627
 Harvest Queen (White-chaffed Red Cross, Salzer's Prizetaker), Resistant selection
 Harvest King, C. I. No. 5647
 Hungarian, Illinois Station
 Indiana Swamp, Illinois Station
 Jones Fife, C. I. Nos. 1942 and 5608
 Kanred, Illinois Station and C. I. No. 5146
 Kharkof, C. I. No. 5661
 Leap, C. I. No. 5618
 Malakof, C. I. No. 5663 and Illinois Station No. 5-460
 Mammoth Red, C. I. No. 2008

Mediterranean, C. I. No. 3467 and Illinois Station
 Michigan Amber, C. I. No. 4864
 Minnesota Reliable, Illinois Station
 Nigger, C. I. No. 5652
 Pesterboden, Illinois Station
 Poole, C. I. No. 5653
 Portage, C. I. No. 5370
 Pride of Indiana, C. I. No. 3492
 Red Cross (red-chaffed), C. I. No. 5318
 Red Rock, Illinois Station
 Red Wave, C. I. No. 5624 and Illinois Station
 Reliable, C. I. No. 3508
 Rudy, C. I. No. 5625
 Stoner (Marvelous), C. I. Nos. 2980 and 5961
 Super (Burbank's), C. I. No. 5544
 Trumbull, C. I. No. 5657
 Turkey, Illinois Station, Nos. -514, 10-110, 12-41, and 509, and C. I.
 No. 6152
 Turkey (Wis. Ped. No. 2), Illinois Station
 Turkey (Iowa No. 404), C. I. No. 5580
 Wheedling, C. I. No. 4846

Judging from the work done by Stevens during the past three years, the
 rosette in Illinois is caused by a species of *Helminthosporium*. The following
 paper by McKinney is also interesting in this connection (McKinney, H. H.
 The *Helminthosporium* disease of wheat and the influence of soil temperature
 on seedling infection. (Abstract). *Phytopath.* 12. Jan. 1922.):

The rosette or *Helminthosporium* foot rot was observed in experimental
 fields in Illinois and Indiana and also in a field of Red Cross wheat near
 Lincoln, Logan County, Illinois. According to various collaborators, control
 measures, especially the use of resistant varieties, are responsible for the
 reduction in the prevalence and destructiveness of the disease.

Foot and root rots caused by *Helminthosporium*

Foot and root rots caused by *Helminthosporium* apparently occur quite
 commonly in various parts of the United States, and may possibly be
 etiologically the same. In fact, it is quite likely that the distribution is
 much more general than is indicated from reports. The damage caused by
Helminthosporium and various other fungi is sometimes obscure and escapes atten-
 tion. Bolley first called attention to this type of disease about 1909, and
 since that time considerable progress has been made in determining more defi-
 nitely the etiology of this class of diseases. Just which species of *Helmin-*
thosporium are responsible for the root rots is still an open question, although
 it is certain from work which has been done at various experiment stations and
 in the United States Department of Agriculture that *H. sativum* is capable of
 causing serious losses. The work of Louise J. Stakman, J. J. Christensen and
 Louise Dosdall in Minnesota indicates very clearly that the worst type of foot
 rot which occurs in that state, and which sometimes severely injures wheat,
 barley and rye, is caused by *Helminthosporium sativum*. The same disease is
 known to occur in other states in the hard red spring wheat area and undoubt-
 edly it is destructive also in the several winter wheat sections. Collaborators
 have not assigned as a cause of the foot rot any particular species of *Helmin-*

thosporium in most cases, but it is quite likely that Helminthosporium sativum is one of those primarily responsible. This Helminthosporium type of root rot has been reported this year from Minnesota, North Dakota, South Dakota, New York, Kansas, and Idaho. It should be noted that according to Melchers two types of foot rot probably occur in Kansas, only one of which is caused by Helminthosporium. The following comments are illuminating:

New York: (Helminthosporium root rot (apparently H. sativum).) This type of injury was very common on winter wheat but on account of the fact that careful counts were not made of the amount of the infection, it would be impossible to say more than that the disease was fairly common on wheat in New York and that it likely caused more loss than was accredited to it. (R. S. Kirby, Aug. 22).

Kentucky: On May 13 and 14 I made an inspection trip through Logan and Christian Counties where there have been reports of considerable trouble in wheat. I was unable to find any signs of the flag smut or take-all, but there was considerable evidence of severe root rot in practically every field that we examined. In the worst fields it appeared to be the cause of severe stunting of certain plants, these plants never attaining a height of more than 3 or 4 inches when they died at about blossoming time. Other plants did not stool out, and sent up only a single short stalk which produced a small, short head; others stooled out and in many cases most of the shoots died when about 4 to 8 inches high. The remainder, however, fruited normally. We have found the same conditions to exist in most of the fields examined about Lexington. The cause of the root trouble I have not definitely determined, but from some work done the past winter on root diseases of wheat, in which about 60 varieties were worked with, I found rather a high percentage of seed infection with Helminthosporium and also some wheat scab infection. There was a marked contrast between fields planted from the ordinary varieties and from pure line selections. Where Ashland was used, the stand, by actual counts made by Mr. Kenney, was 25% better than the stand of Currell's Prolific which is a mixture of strains. This increased stand was due primarily to a greater uniformity in the number of culms produced, practically none of the severely stunted plants being found. It appears from our work so far that this root trouble may be handled to quite an extent by selecting resistant strains and eliminating the low yielding very susceptible strains from our varieties. I feel fairly confident that the percentage of seed infection with pathogenic organisms capable of causing root rot is sufficiently high so that practically complete root infection will take place in the field very soon after the seed is sown. (Valleau).

Oklahoma: (Referring to specimens sent by Robert Stratton.) I find No. 6 (wheat from Beaver County) to be wheat apparently affected with a species of Helminthosporium, known to be more or less common as a cause of foot rot in certain sections of the country. (H.B. Humphrey).

Illinois: Traces in Madison and Logan Counties. (Dungan).

Minnesota: A serious root and foot rot of rye, barley, and wheat was found in every county visited. The disease was most serious in the following counties: Wilkin, Marshall, Pennington, and Kittson. It was quite severe in localized areas of Anoka, Ramsey, and St. Louis Counties. Roots and bases of culms of infected plants were plated out on nutrient media. In nearly every case a species of *Helminthosporium* was isolated. *Fusarium* was seldom present in the cultures, although it often appeared to be present on the dead leaves and bases of culms, and it was apparently secondary in most cases.

The disease appears to be most severe on light soil such as peat and sand. This was apparent from the observations made in Marshall, Kittson, Pennington, St. Louis, and Anoka Counties. The disease was also observed to be extremely severe on heavy soil. One of the most severe infections was found at Fens, a peat experiment station near Duluth. Several plots of wheat and barley, including several varieties of each, were almost completely destroyed.

I did not see a single field of wheat or barley free from foot and root rot caused by *Helminthosporium* sp. I saw heavily infected fields, both of wheat and barley, following potatoes and other cultivated crops, but as a rule the disease showed up most where wheat, rye, and barley were grown continuously or where poor cultural methods were practiced. Weather, poor soil, cultural methods which tend to hinder normal growth of the plants, all favor the development of the fungus. *Helminthosporium sativum* has been shown to be one of the commonest causes of the disease in Minnesota. (J. J. Christensen).

North Dakota: This disease in wheat, each year, is becoming more and more destructive, acting as a seedling root blight. It has this year very materially aided the drought and hot weather to reduce the crop, not only in the Red River Valley, but in the western portions of the state. It has been particularly destructive on certain of the rust resistant durumms such as Monad and Pentad. (Bolley).

South Dakota: I have just heard from Mr. McKinney on the wheat which I sent from the field near Aberdeen which gave indications of being take-all. He informs me that he has isolated *Helminthosporium* from it. I have had Professor Hutton test the soil where this wheat was growing and he informs me that there is about 1.25% alkali which is enough to cause serious damage to the crop. (Arthur T. Evans, July 2).

Kansas: We have isolated at least two species of *Helminthosporium* which have come out in practically every specimen that we have cultured. While Dr. McKinney and I have not compared our cultures microscopically we have compared them from the Petri dishes and apparently have gotten the same organism.

As the matter now stands, it seems as though we have two distinct problems in the state. The one in Dickinson County where the wheat is dying out in spots, has also been found at our

agronomy farm here in Riley County. Probably the same trouble exists in Cheyenne and Ellis Counties. From the majority of fields which have been reported injured and where Mr. Pearson has made examinations, we find another trouble which no doubt is the most common in the state this year. Plants are dying more or less all over the field. I attribute this injury to a number of factors in combination with one another.

The late freezes caused a great deal of refuse to accumulate on the ground and chiefly around the crown of the plants. In many places there was a considerable lack of rain. The soil also has been seriously depleted in many of these fields. Placing the plants under these conditions, together with excessive tillering, has produced a strain on the root system which it cannot meet. I believe that a great deal of this refuse material is a harboring place for semi-saprophytic and partially parasitic organisms which together with the organisms in the soil, have been responsible for a decay in the root system.

No doubt a number of imperfect fungi are entering into this problem. In most cases they are causing a distinct rotting of the roots under ground without very much discoloration on the lower internodes. This I believe is responsible for a great deal of our poor wheat this year. Under more or less normal conditions, this would not have been nearly so noticeable; but where wheat is grown year after year on this land, the conditions are favorable. (Melchers, June 6).

Idaho: Root rot, evidently due to Helminthosporium sp., is rather common around Rexburg in Upper Snake River Valley. Only wheat on dry land affected. Loss in regions affected may reach 4%. This season evidently favorable for the development of this trouble. Cold, wet spring followed by hot, dry weather. In winter wheat greatest injury where snow lay late in the spring. Same trouble later found near Paris in extreme southeastern Idaho. (Hungerford).

Literature

Hamblin, C. D. "Foot rot" of wheat caused by the fungus Helminthosporium. Agr. Gaz. N.S.W. 33: 13-19. Jan. 1922.

Other Foot and root rots

Undoubtedly, many other fungi under certain conditions also cause foot and root rots on wheat and other cereals. Mackie calls attention to the fact that Fusarium causes a serious root rot in California; and in Washington, Kansas, Kentucky, and Oklahoma there are rather destructive foot rots, the cause of which has not yet been ascertained. Stratton reports that in Oklahoma a disease, known as white heads, is present in nearly every field. The loss ranges from a trace to 20%, with an average of about 2%. He states that the disease is most destructive in fields in which continuous wheat culture is practiced, and that the diseased spots are where wheat has been pastured or where animals have stood. Melchers points out that there are two distinct types of foot rot in Kansas, one of which may be caused by Helminthosporium and the other of which resembles

take-all. This disease is described in a paper presented at the Toronto meetings by McKinney and Melchers (McKinney, H. H. and L. E. Melchers. Foot-rot disease of wheat in Kansas. (Abstract). Phytopath. 12: 28-29. Jan. 1922.) A similar disease has been observed by Mackie and by Johnson in California.

One of the big problems confronting cereal pathologists is that of foot and root rots.

Nematode (Tylenchus tritici (Stein.) Bast.)

The nematode of wheat was reported from Virginia, West Virginia, North Carolina (first report in 1921), and Georgia. In Virginia the disease was slightly more prevalent than it was last year, and than it is in an average year. The loss for the entire state is estimated at .2%. According to Fromme there were no severe attacks, but the disease occurred in small amounts in those sections in which it was previously known. In West Virginia, according to Giddings, the disease occurred only in the southeastern portion of the state, except for some local attacks in Mason County. The maximum percentage in any one field was 5, and the reduction in yield for the entire state, according to Giddings, was slight. In North Carolina, the nematode disease was reported for the first time, in Wilkes County. Foster states that the disease was prevalent in two sections where it probably caused a loss of from 10 to 20% of the crop. According to the farmers, it was rather common in the same sections last year, and some of them stated that they had seen the disease for the past five years. The disease occurs also in Jackson County, Georgia. This is the only county, McClintock says, in which it is known in that state.

It was not as destructive in 1921 as in 1920 although it is said to be quite important in Jackson County. The accompanying map (Fig. 46) shows the present known distribution of wheat nematode.



Fig. 46. Distribution of wheat nematode, Tylenchus tritici.

Black chaff caused by Bacterium translucens var. undulosum Smith, Jones & Reddy

Black chaff was reported as occurring only in Arkansas, Kansas, Colorado, Iowa, Nebraska, South Dakota, and Montana. It did no appreciable damage, accord-

ing to collaborators, except in Nebraska, in which the reduction in yield is estimated as a bare trace, and in Montana, in which Jennison estimates that the yield was reduced by 1.5%. The following comment by Jennison summarizes the situation in that state:

"Very common throughout state and the cause of considerable shrinkage in late-planted fields. First significant outbreak since 1918. Appears to have been confined for most part to dry land spring wheat districts. Rapid spread during warm, moist spring. Hot dry weather in late July and August checked it. Found on Marquis and durum."

In Wisconsin the disease was found only in experimental plots of Kanred wheat, the seed of which had been grown in Kansas.

Anthracnose caused by Colletotrichum cereale Manns

Anthracnose occurred in the following states: New York, New Jersey, Pennsylvania, Maryland, Virginia, Tennessee, Arkansas, Ohio, Indiana, and Illinois. Miss Detmers states that in Ohio infection was generally present in fields in the central and southern parts of the state, particularly in fields severely attacked by leaf rust. The estimated reduction in yield for the state is 1%. In Illinois, the estimated reduction is .2%, and in the other states the disease did no appreciable damage for the state as a whole or it reduced the yield by only a bare trace. Fromme reports that anthracnose was severe in occasional fields in the south central part of Virginia. Apparently, however, the disease was unimportant except in Ohio.

Glume blotch caused by Septoria glumarum Pass.

Glume blotch of wheat was reported from the following states: New York, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, Kentucky, Tennessee, North Carolina, Arkansas, Ohio, Indiana, Illinois, Wisconsin, Iowa, Minnesota, and Nebraska. It apparently did not cause serious damage in any one of these states. The highest percentage of reduction in yield was reported from Arkansas, where Elliott estimated that the yield had been reduced by 1%. In practically all of the other states in which the disease occurred, it is reported merely as occurring, but not as being destructive except in some localities. However, it was important in certain places and under certain conditions. Possibly after more information has been obtained it may be shown to be more destructive than it is now supposed to be.

Fromme reports that the disease sometimes causes local damage in Virginia. He states that many plants are severely dwarfed and the heads are injured on account of infection of the rachis. The disease was epidemic in Pittsylvania County, but was relatively unimportant in other sections of the state. Rosen comments as follows on the situation in Arkansas and calls attention also to the destructiveness of the disease in Australia:

"I am prepared to say that this is a rather serious thing with us, standing right next to leaf rust, Puccinia

triticultura, in severity of attack. It seems to me that this is a disease of importance from a national standpoint, judging from the outbreaks in this state. Particular attention ought to be given in the states adjoining Arkansas, for I am under the impression that I saw this thing two years ago in Missouri, although I have no specimens and am not certain of this.

"I have just received a statement from Dr. W. B. Grove of England, in which he tells me that while the disease is not serious in England, it is as serious in Australia as it is in our state."

In Arkansas Technical Bulletin 175, May 1921, Rosen states that the correct name of the organism is Septoria nodorum Berk. The following names would be synonyms: Septoria glumarum Pass., (?) Septoria fusispora Died., Phoma Hennebergii Kuehn., Phoma Hennebergii (Kuehn) Berl. and Vogl., and (?) Ascochyta graminicola Sacc. in part. Rosen says that wheat in the vicinity of Fayetteville has been severely attacked for three successive seasons. The disease occurs on many varieties. It has been located in Independence County, as well as Washington County, which are widely separated; and probably occurs in other localities. According to Rosen, the disease has been reported from Maryland (Townsend 1898; severe injury), and Ohio (Selby, 1898), and perhaps also from Wisconsin (Davis) and Connecticut (Clinton, 1918). The use of early maturing varieties, proper crop rotation and clean seed should be successful in controlling the disease.

Another publication on this subject which will be interesting is that by Weber. (Weber, George F. Studies on Septoria diseases of cereals and certain grasses. (Abstract). Phytopath. 12: 44. Jan. 1922.)

Fromme gives the following observations on the percentage of severely infected heads of different varieties at the Chatham sub-station: Red May 95, Fulcaster 85, Fultz 70, Red Amber 65, Leap's Prolific 65, Stoner 25, Fulcaster Selection (seed treated by hot water method) 25.

Septoria leaf spot caused by Septoria graminum Desm.

Leaf spot caused by Septoria graminum was reported in 1921 from the following states: New York, Delaware, Maryland, Virginia, West Virginia, Kentucky, North Carolina, Arkansas, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Missouri, Nebraska, Kansas, Idaho, Oregon, and California. Apparently it caused but little damage in most of them. The greatest reduction in yield was .5% in Maryland. In all of the other states it was reported that the disease either did no appreciable damage or only a trace. The following comments are interesting:

Virginia: Severe in Pittsylvania County, accompanying glume blotch. (Fromme).

Kentucky: Open warm winter and very warm period in March made weather conditions favorable, but the percentage in loss was none, or very slight. (Valleau).

Tennessee: (Observations made during April, May, and June in the vicinity

of Knoxville, Murfreesboro, Columbia, Nashville, Jackson, and Union City.) Leaf spot had been found early in April very common in most of the fields from Columbia to Union City. In several fields near Nashville the leaf spot was present to the extent of about 10% of the plants. However, in many fields only traces of it could be found. The damage caused was probably slight. (Sherbakoff).

Nebraska: Common in fall of 1920, uncommon in spring of 1921, on winter wheat. (Goss).

Oregon: Apparently confined to western Oregon from north to south, in region of mild, moist winter conditions. (Barss).

Recent literature

Weber, George F. Studies on Septoria diseases of cereals and certain grasses. (Abstract). Phytopath. 12: 44. Jan. 1922.

Ergot caused by Claviceps purpurea (Fr.) Tul.

Ergot of wheat was reported from Virginia, North Carolina, Illinois, Wisconsin, Minnesota, North Dakota, and Nebraska. In Virginia the loss was very slight, according to Fromme; in Illinois the loss was a trace only. and in

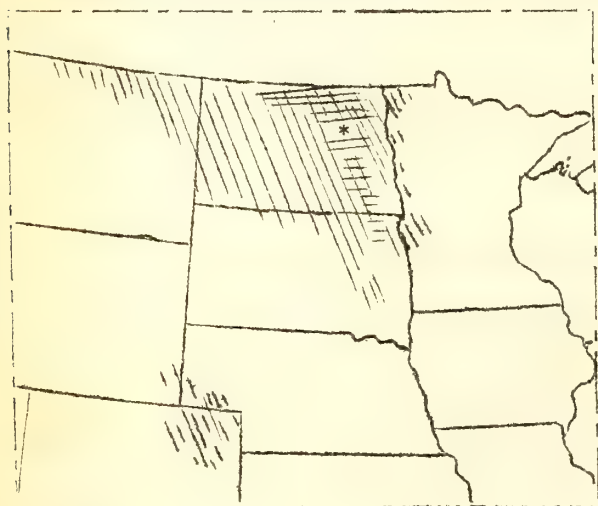


Fig. 47. Approximate intensity of production of durum wheat. Ergot worst in region with * as center. Durum wheat area and area of heavy ergot infestation practically coincide.

Wisconsin the infection was said to be general but very light. The disease has been increasing in severity in the durum wheat regions of Minnesota and North Dakota (Fig. 47). Durum varieties seem to be especially susceptible. In the rust nursery at University Farm, St. Paul, Minnesota, some durum varieties are severely attacked and some of the durum common wheat hybrids also seem to be very susceptible. It is quite noticeable that during the past few years the increase in the severity of the disease has become an object of concern to growers and semolina manufacturers. It is said that the presence of more than 1/10 of 1% ergot in flour or semolina is dangerous. In many samples of durum, from the 1921 crop, the percentage of ergot bodies is as high as 2% or 3% and in some lots of wheat it is as much as 10%. In fact, in some of the durum-

growing regions the flies which spread the conidia were so numerous as to lead the farmers to believe that the insects themselves were doing the damage. Bolley writes that ergot was epidemic in the region of North Dakota, northeast of Devil's Lake, and that entire fields were practically destroyed in that region.

While ergot has not been so destructive in Minnesota durum fields as in those of North Dakota, still it has been present in appreciable amounts and in some samples of wheat there have been from 2 to 4% of ergot bodies. Unless natural conditions become unfavorable for the development of the disease it will become necessary to use control measures.

The following comment, taken from the New Macaroni Journal, Minneapolis, Minnesota, December 15, 1921, (Vol. III, No. 8, p. 20) gives an idea of the situation in the durum wheat growing sections of the northwest:

"Samples submitted to the government officials from sections of North Dakota show as high as 10% of ergot after threshing. This does not fully represent the amount of ergot produced with the crop for an appreciable percentage of the sclerotia, as the small ergot bodies are known, would of course be blown out with the foreign materials as part of the screenings or the straw.

"While this disease is not a new detriment to cereal culture, having been found in various sections of the grain country for many years, it is just the last few years that its effects have been felt. Investigations show that it is not only much more prevalent than ever before known but also that it is more widely distributed.

"Durum wheats seem to be more subject to this disease than the ordinary bread wheats. This opinion is based on field observations and a study of samples of durum, which show a higher percentage of ergot in the durum varieties."

Powdery mildew caused by Erysiphe graminis DC.

Powdery mildew was observed in the following states: New York, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, Kentucky, Tennessee, Arkansas, Ohio, Wisconsin, Minnesota, Kansas, Washington, Oregon, and California. It was reported as present without doing any appreciable damage except in New York, Pennsylvania, and Virginia. In New York the damage was estimated by Kirby to be 1%, while in Pennsylvania, Virginia, and Oregon it was a trace. Fromme states that in Virginia the disease was occasionally severe. In Kentucky, Valleau found it particularly on young plants and on plants which had lodged. The following comments give some idea of the situation in several states:

New York: On account of the early warm spring this fungus attacked the wheat very severely and caused considerable damage which may have reached 1 or 1.5%. (Kirby).

Pennsylvania: Caused considerable alarm in the spring but dry weather checked it and it apparently did little harm. (Thurston and Orton).

Delaware: First observed April 8. Associated with considerable yellowing in fields but not seriously affecting growth. (Adams).

Montana: Some damage in irrigated sections where grain lodged.
(H. E. Morris).

WHEAT - Powdery mildew, downy mildew, and leaf spot

Oregon: The only serious damage in certain spring grain fields in the northern Willamette Valley. (Barss).

Downy mildew caused by Sclerospora macrospora Sacc.

Downy mildew of wheat, which had previously been unknown in the United States, was found during the past season in Jackson and Obion Counties, Tennessee, and in Fulton County, Kentucky. Herbarium specimens in the University of California show that the disease occurred in Kings County, California, in May 1919. W. H. Weston points out that the disease occurs mostly on low lying, poorly drained fields. The present known facts regarding the disease are summarized by Weston in Department Circular 186. (Weston, William H. The occurrence of wheat downy mildew in the United States. U. S. Dept. Agr. Circ. 186: 1-6. June 1921.)

Leaf spot associated with Penicillium sp.

A report of a leaf spot which was associated with a species of Penicillium was received from Forest Grove, Oregon May 27. On plants two or three inches high there were while withered spots on the leaf blades, which fell over. Only one field was affected. The weather had previously been cool and moist, and with the return of bright weather a week later the field recovered. The variety was Marquis, and had been seeded late.

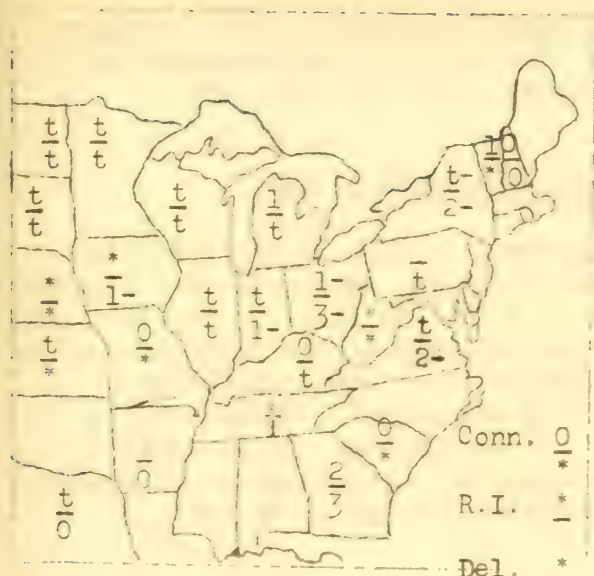
RYE

Stem rust caused by Puccinia graminis Pers.

The stem rust of rye was relatively unimportant during the past year. The only states in which the yield was reduced appreciably were in Ohio, Michigan, and Minnesota. In each of these states the percentage of reduction in yield is estimated as 1%. While the rust was present in many other states as indicated on the map (Fig. 48) it was not important economically. This is very probably due to the fact that rye matures so early as to escape rust damage. In Michigan, according to Coons, there was decided local effect near barberries. Heavy infection occurred in some fields near rusted bushes. The same observations were made in Indiana, Illinois, and Minnesota.

Rhode Island: Very common this year in uredo stage. Caused serious destruction of leaves. (Browning).

Michigan: Heavy rusting; loss probably not more than 5%. Epidemics near barberry locations in southwestern Michigan with no general infection in district. (Coons).



*=Occurrence, no data
on loss
-*=Less than in 1920
Upper figures = % reduction due to stem rust
Lower " " " " " leaf rust

Indiana: Locally serious in vicinity of barberies. Noted in north-eastern counties. (Jackson).

Minnesota: First reported about June 20 in Freeborn County. Fairly heavy on late rye. In some localities the yield probably was reduced by as much as 5%. (Department of Plant Pathology).

Nebraska: Stem rust was very general throughout the state on rye, but the infection was light. (Thiel, A. F. Cereal Courier 13: 141. July 20).

Fig. 48. Estimated losses from stem rust (upper figures) and leaf rust (lower figures) of rye, 1921.

Leaf rust caused by Puccinia dispersa Eriks.

The leaf rust of rye apparently caused some reduction in yield in several states during the past season, although it was relatively uncommon. The distribution of the disease and the amount of damage done are indicated on the map given under stem rust (Fig. 48). The urediniospores of the leaf rust of rye overwinter commonly and readily so that there is almost always sufficient inoculum to cause fairly general rust attacks, even in the northern rye-growing states, such as Michigan, Wisconsin, Minnesota, and the Dakotas. However, the rust seldom does any real damage in the principal rye growing states on account of the early maturity of the crop. During the past year Clayton estimated that the yield was reduced in Ohio by 3%, McClintock estimated the same for Georgia, Kirby estimated 2% in New York, and Fromme, 2% in Virginia. Aside from these states, however, the damage was insignificant.

Recent work conducted by Mains throws new light on the life history of the leaf rust parasite.

"Efforts to obtain an infection of the leaf rust on Anchusa indicate that there may be two races of the rye rust, one of which may parasitize some other heteroecious host than Anchusa. An effort to determine this host will be made." (Mains, E. B. Cereal Courier 13: 66. April 30, 1921.)

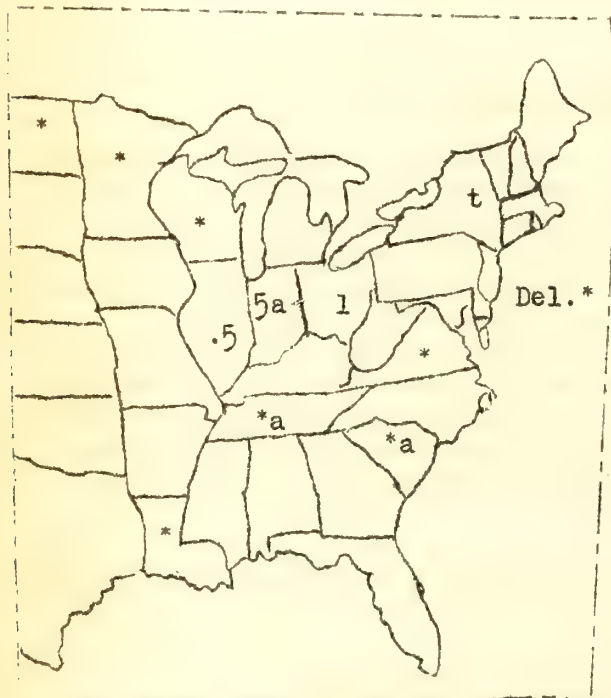
The possibility of developing rust resistant varieties of rye is suggested by Mains and Leighty (Mains, E. B., and C. E. Leighty; Rye resistant to leaf rust Puccinia dispersa (Abstract). Phytopath. 12: 33. Jan. 1922.)

Scab caused by Gibberella saubinetii (Mont.) Sacc.

The head blight, or scab, of rye was observed in 1921 in the following states: New York, Delaware, Virginia, Indiana, Illinois, Wisconsin, and Missouri. It apparently did not reduce the yield in any of them. In fact, in New York only a single scabbed head was found, and, while small amounts of the disease could be found in many places in several of the other states from which reports were received, the disease did not reduce the yield to any extent. While scab probably is more prevalent on rye than on any one of the other small grains except wheat, it apparently seldom does any appreciable damage unless by causing seedling blight. The head blight is seldom prevalent enough to be very destructive.

Anthracnose caused by Colletotrichum cereale Manns

The anthracnose of rye was reported from the following states: New York, Delaware, Virginia, Tennessee, South Carolina, Louisiana, Ohio, Maryland, Illinois, Wisconsin, Iowa, Minnesota, and North Dakota (Fig. 49). In most of the states the disease was not especially important. However, in some of them



it did some damage locally. In Tennessee, according to Sherbakoff, Hesler, and Essary, the disease did considerable damage. In South Carolina, Ludwig states that the damage was serious locally, particularly in one locality in which the heads were severely injured. In Ohio, where culm infection was severe enough to cause considerable kernel shriveling, the reduction in yield is estimated at between .5% and 1%. In Indiana there was a great deal more of the disease than had ever been reported before. The following statement made by J. B. Kendrick summarizes the observations in Indiana:

"A farmer, Mr. August H. Greiger, reported a serious trouble in his fifty-acre field of Rosen rye in Porter County. He reported a fungus or mould growing on the roots and the rye dying. On examination, I found the trouble to be anthracnose, and very serious. From 40-60% of the rye was dead, the trouble being rather

*=Occurred, loss not known
(a)=See comments in text

Fig. 49. Percentage loss from rye anthracnose in 1921.

uniformly distributed over the fields. The stalks were dead at the crown, and there was lots of infection on the heads. I examined 50 acres nearby, and found anthracnose present, but not as severe as on the farm of Mr. Greiger. There was 8-10% of the rye dead in these fields. The reports of the farmers visited were that the rye was generally affected by this trouble and it was causing them considerable worry for fear it was the same trouble they had in wheat in 1919. There is no doubt but that their trouble is anthracnose.

In Illinois also the disease was much more prevalent, according to Dungan and Tehon, than in 1920 although the reduction in yield for the entire state is estimated at .5%. In Wisconsin the disease was present in destructive amounts only in Forest County, while in Minnesota and North Dakota it was present but apparently did no appreciable damage. It is possible that the disease actually causes greater reduction in yields than is generally supposed. It is quite probable that some of the damage is overlooked, although in the principal rye-growing states it is quite likely the estimates are fairly accurate. Gardner suggests that in Indiana the reason for the heavy attack was the excessive rains during May and the first part of June.

Powdery mildew caused by Erysiphe graminis DC.

Powdery mildew was observed in the following states: Delaware, Maryland, Virginia, Kentucky, Arkansas, Wisconsin, and California. It apparently did no appreciable damage in any of them except in Maryland, in which Temple and Jehle estimate that the yield was reduced by about 1%. While the disease occurs on rye under exceptional conditions in practically all of the rye-growing states, it is seldom prevalent enough to attract any particular attention and usually is of no economic importance.

Stem smut caused by Urocystis occulta (Wallr.) Rab.

The stem smut of rye was observed in the following states: New York, New Hampshire, Virginia, West Virginia, Maryland, Michigan, Wisconsin, Iowa, and Minnesota. The highest percentages of infection recorded are between 2% and 3% in Indiana, although undoubtedly individual fields in some of the other states contained considerably more smut. The damage from stem smut of rye quite often is overlooked because it is rather difficult to detect after the plants have begun to ripen. The reduction in yield was 1.5% in Iowa, .5% in Minnesota, and all of the other states reported only a trace. The disease can be controlled rather readily by means of seed treatment and rotation. It is known that the spores will live in the soil from harvest time until sowing time in the same season. However, by the following year practically all of the spores have germinated and the danger of soil infection is thus eliminated.

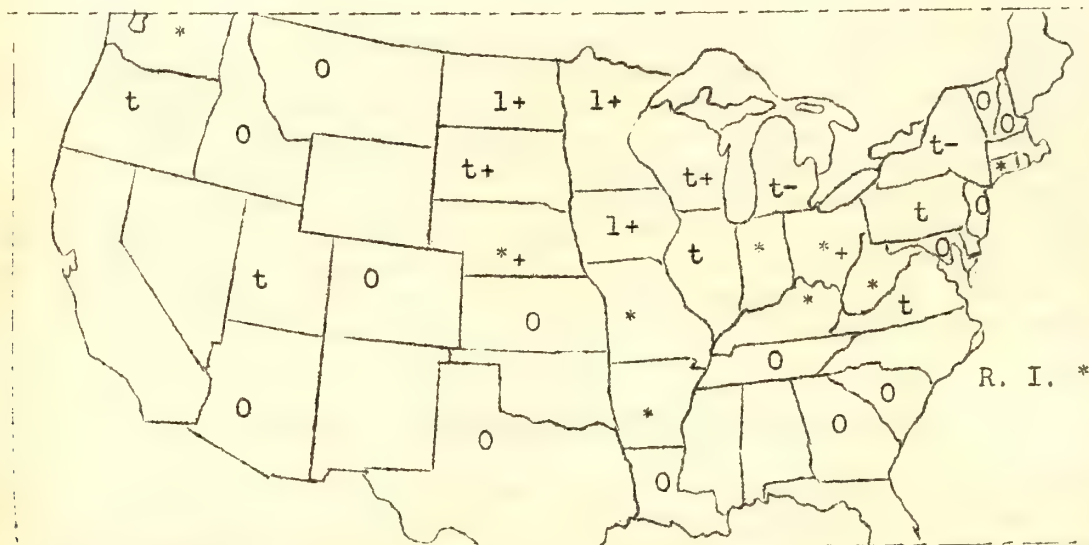
Head smut caused by Ustilago sp.

Head smut of rye, the identity of which is still somewhat in doubt, was found in two states during the past year. In New York the disease was found on

volunteer rye in a wheat field near Ithaca, but was not observed elsewhere in the state. C. T. Gregory states that smutted heads were received also from Kosciusko County, Indiana.

Ergot caused by Claviceps purpurea (Fr.) Tul.

The distribution and losses caused by rye ergot are indicated on the accompanying map, Fig. 50. It will be noticed that the disease did very little



0=Not observed
 *=Occurred but loss negligible
 +=More than 1920
 --Less " "

Fig. 50. Occurrence of ergot of rye in 1921.

damage during the past year. The greatest reductions in yield are reported from Minnesota and North Dakota, in both of which the yield is estimated to have been reduced by 1%. In most of the other states the yield was not appreciably affected. Apparently the disease was more prevalent than in the previous year in Wisconsin, Minnesota, the two Dakotas and Ohio. In the other states it apparently was about the same as or even less injurious than in 1920. Evans states that in South Dakota there was a great deal of ergot on Dean rye but only a little on Swedish and Advance, the two best varieties in South Dakota.

Recent literature

Seymour, E. K. and F. T. McFarland. Loss from rye ergot. *Phytopath.* 11: 285-289. July 1921. (Nov.).

Take-all caused by Ophiobolus cariceti (Berk. & Br.) Sacc.

The true take-all of rye was reported from New York. Kirby states that it occurred in Monroe County only, and on only one plant.

Foot and root rots

Root rot in Indiana

Special note is made by collaborators of what appear to be three types of root rots. Jackson found what appears to be a new type of root rot of rye in Indiana. The following quotation is from a letter to Dr. G. R. Lyman regarding the root rot in Indiana.

"I made a trip last week in Porter, LaPorte, and Starke Counties, and ran across a peculiar root rot of rye in Starke County. The plants were dying in large patches shortly after heading out. The plants had somewhat the appearance of those badly affected with anthracnose, but this fungus was not present. The roots, however, were rotted off, but without any evidence of fruiting bodies which could account for the trouble. Cultures have been made from these roots and the bases of the stalks. A fungus seems to be present, but I can not yet be sure whether we have the causal fungus. In fact, it would probably take some investigation to determine whether the fungi which we have isolated will cause a root rot in rye. The disease seems to be different from anything I have seen described on rye." (H. S. Jackson, June 27).

Foot and root rot caused by *Helminthosporium sativum* P. K. & B.

J. J. Christensen reports that a destructive foot and root rot caused by *Helminthosporium sativum* was fairly prevalent and destructive in some localities in Minnesota. The disease causes a stunting of the plants and blasting of the heads. This disease was quite destructive in Minnesota in 1919, apparently less destructive in 1920, but quite destructive again in 1921. It is estimated that the disease was found in at least 90% of the fields of the state.

White heads

Stratton reports that in Oklahoma white heads, such as is described for wheat, also occurs on rye (see wheat - miscellaneous foot rots).

Miscellaneous diseases

A disease similar to black chaff was found by Evans in South Dakota. He writes as follows:

"I have found one new disease on rye, rather similar to black chaff on wheat, but the organism has not been identified or named as yet. It was only found in one field and then doing only a medium amount of damage."

Bacterial leaf spot. Hungerford found a bacterial leaf spot of rye in northern Idaho but no complete description is yet available.

Covered smut caused by Ustilago hordei (Pers.) K. & S.

Covered smut of barley is found practically wherever barley is grown, although during the past year it apparently did not do very much damage. The greatest reduction in yield is reported from Tennessee (4%). In Kentucky, according to Valleau, the loss was about 3%; Fromme estimated that the yield

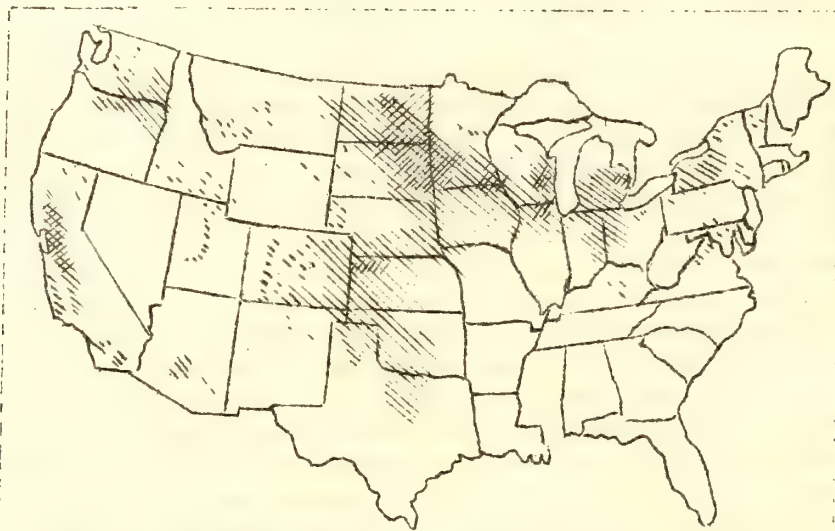


Fig. 51. Distribution of barley in the United States. (Map prepared in the Office of Farm Management.)

in Virginia was reduced 2%; and Taubenhaus estimated that the loss in Texas was about the same. The loss in Montana was also about 2%, according to Jennison. The disease did not cause more than 1% loss in any other state from which reports were received and in most of them the loss was only a trace, although the percentage of reduction in some individual fields was high. The loss in Arkansas was placed at 5% but practically no barley is grown in that state, according to Elliott. In Kansas, according to Melchers there was as much as 50% of smut in some fields, while in Missouri 30% of the heads in some fields were affected, and in Indiana the highest percentage of smut in any individual field was 15. In Coahuila, Mexico, according to Christopher and Stakman, smut was very general. The percentage of infected heads in various fields ranged from 5 to 20. For distribution and losses see the map, Fig. 52.

The disease is controlled easily by ordinary seed treatment, including the modified hot water treatment for loose smut. The results of experiments to determine varietal resistance apparently were disappointing. The following comment from the Cereal Courier summarizes the work done at Arlington Farm, Virginia in 1921:

The experiments for testing the behavior of varieties of barley toward infection by the covered smut fungus were as usual unsuccessful. So far, practically all attempts at getting infection by smutting the seed at the time of sowing have met with little or no success. Some varieties show a slight increase in the percentage of infection when the seed is smutted, while others do not. Seed of most varieties

when taken from a smutty field produce some infected plants.

Smutted seed sown October 9 produced more smut than smutted seed sown October 30. However, very few varieties showed infection in either case and the percentages were low.

In the seed treatment plats hot water proved to be very effective in controlling both the smuts of barley. Formaldehyde was almost as effective as hot water in controlling the loose smut, but less effective against the covered smut. This is the reverse of what one might expect. It is more effective against covered smut in some varieties than in others. (W. H. Tisdale. Cereal Courier 13: 280-284. Dec. 30.)

Mackie comments as follows on the conditions in California:

"Hidden smut of barley is very rare in the state this year. In the Salinas Valley and in the coast counties of Southern California the attacks were the most severe amounting, however, to no more than 5% in the fields attacked." (July 1).

"Covered smut of barley is apparently affected by climatic and soil conditions to a marked extent. The low lying river or lake bottom lands usually show the most barley smut. The percentage of attack appears to be greater on wet years.

"Experiments in California have for three years failed in attempt to create heavy smut attacks by artificially inoculating barley seed. This has been the experience of other investigators. It has therefore been impossible to determine the smut resistance of any of the hundreds of barley varieties under test.

"While inspecting the barley being prepared for foreign shipments at Port Costa, it was noticed that the majority of the lots examined showed considerable smut. It is difficult to form an estimate of the losses from the appearance of smut in the sacked grain but undoubtedly it is very considerable." (August 1).

Loose smut caused by Ustilago nuda (Jens.) K. & S.

The loose smut of barley occurred in practically every state in which barley is grown. It was reported this year from the states which are indicated on the map, Fig. 52. The losses were not particularly serious in most states, although the losses were quite heavy in Pennsylvania (4-5%), Virginia (5%), Kentucky (6%), Tennessee (2%), Oklahoma (3%), Montana (2%), and Arkansas (15% - very little barley grown). In most of the other states the yield was reduced by 1% or less, although the percentage of infection in individual fields was sometimes fairly high; in Michigan, for instance, from 1 to 10% and in Montana as many as 15% of the plants were affected, while Evans states that in South Dakota 20% of the heads were smutted in some fields.

Apparently the hot water treatment is little used. In fact, the replies to a special questionnaire show very clearly that most of the collaborators

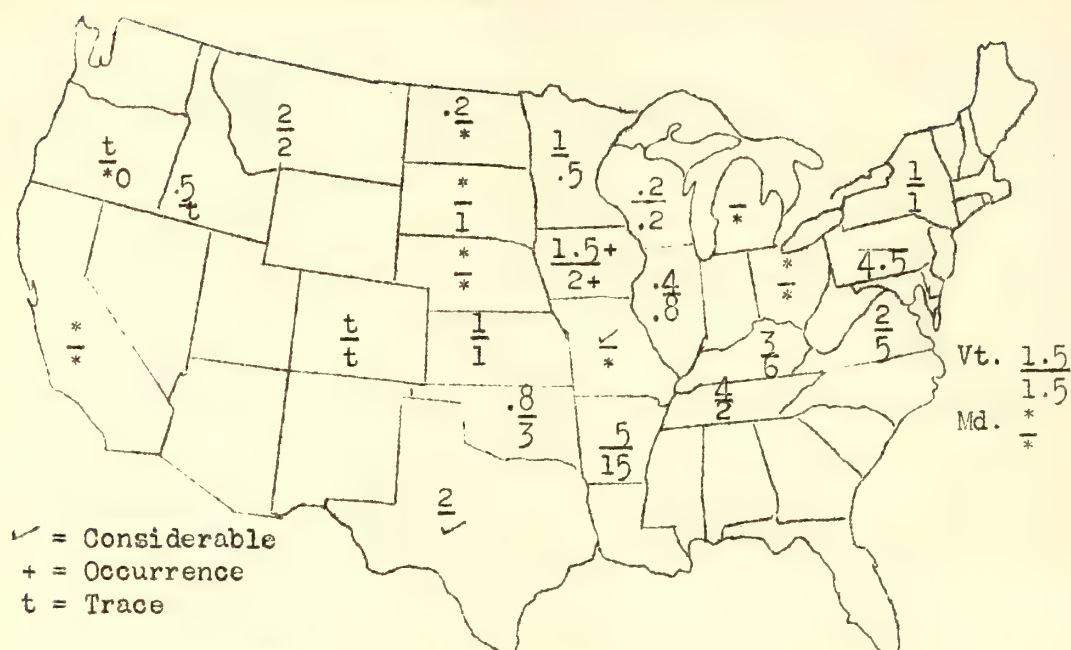


Fig. 52. Covered and loose smuts of barley. (Upper figures represent covered smut; lower figures, loose smut.)

consider that the loose smut of barley is of minor importance and that it is not sufficiently injurious to necessitate treatment. In a few states, however, central treating plants have been used. Giddings reports that in West Virginia the modified hot water treatment has been used to some extent in the eastern part of the state, but only in small areas and under the supervision of county agents and also of some representative from the experiment station. He states that in about 50% of the seed lots, germination was not affected while in the others the viability was somewhat reduced. In Virginia, according to Fromme, the hot water treatment was used on barley during the past year, and controlled almost entirely both the loose and the covered smuts. The treatment was carried out at central treating plants. The following comment by Taylor, concerning work conducted at the Arlington Farm, is interesting:

The fortieth-acre plats of barley treated for smut by Dr. G. M. Reed show as conclusive results as last year. All varieties in the varietal experiments for the current year were treated by the hot water method and a general examination of these plats has shown but two smutted plants, both covered smut (*U. hordei*). The ten plats treated with formalin show occasional plants infected with covered smut. The ten untreated plats have a heavy infection of both loose and covered smuts. (Taylor, J. W. Cereal Courier 13: 70. May 10, 1921.)

Bolley suggests that the disease is at least partly amenable to the proper kind of formaldehyde treatment, and says that it is much reduced on all farms on which proper seed treatment is practiced persistently.

Stem rust caused by Puccinia graminis Pers.

Stem rust did not injure barley appreciably in most states during the past year. This probably is due to the fact that the host matures so early as to escape severe rust infection. However, the local loss was in some cases considerable. Kirby reports that infection was considerably heavier in New York on barley than on wheat, probably on account of the fact that the Puccinia graminis secalis strain of rust is more commonly distributed from the barberry. This probably is due to the prevalence of Agropyron repens, which is susceptible to the secalis strain but not to the tritici form. Tehon and Dungan state that in Illinois the stem rust of barley was present, especially near barberry plantings. Vaughan reports that the stem rust of barley was more prevalent in Wisconsin than usual and, while there was no rust on early plantings, the later plantings were rusted, although the loss was only a trace. In Minnesota also the infection was heavier than usual, and the yield probably was reduced by about 3%, although it was difficult to differentiate between heat injury and rust. In Iowa the reduction in yield is estimated at 7%, by Melhus, who says that there was very much less rust than during 1920. Bolley comments as follows on the occurrence of rust in North Dakota:

"Stem rust of barley was not a factor of great importance to reduce the crop this year. Far more damage was done by the heat and drought which shortened the life of the crop and perhaps held the rust in control."

Thiel suggests that there undoubtedly was a reduction in yield in Nebraska on account of the heavy general infection. According to Mackie, the stem rust usually is not very injurious in California but it was more prevalent in 1921 than in previous years. He states that some entire fields were ruined. The only states from which percentages of the reduction in yield are available are Vermont (1%), Michigan (1%), Wisconsin (1%), Iowa (7%), Minnesota (3%), and South Dakota (2%). See map, Fig. 53, for distribution and losses.

Stripe rust caused by Puccinia glumarum Eriks. & Henn.

Report cards were received from Montana, Colorado, Idaho, Washington, and Oregon, but in no one of these states was the yellow stripe rust reported on barley during the past season.

Leaf rust caused by Puccinia simplex (Koern.) Eriks. & Henn.

The known distribution of Puccinia simplex in the United States is indicated on the accompanying map, Fig. 53. The rust was observed during the past season in Vermont, New York, Texas, Illinois, Iowa, South Dakota, Nebraska, Kansas, Montana, Colorado, Oregon, and California. It apparently did no real damage in any of these states. Mackie reports that it was present in California, particularly in the Sacramento Valley, and in the coastal regions where it appeared during May but that it seemed unimportant. It seldom has been severe enough to attract much attention except in California. A small amount was found in May in the state of Coahuila, Mexico by Stakman and Christopher.

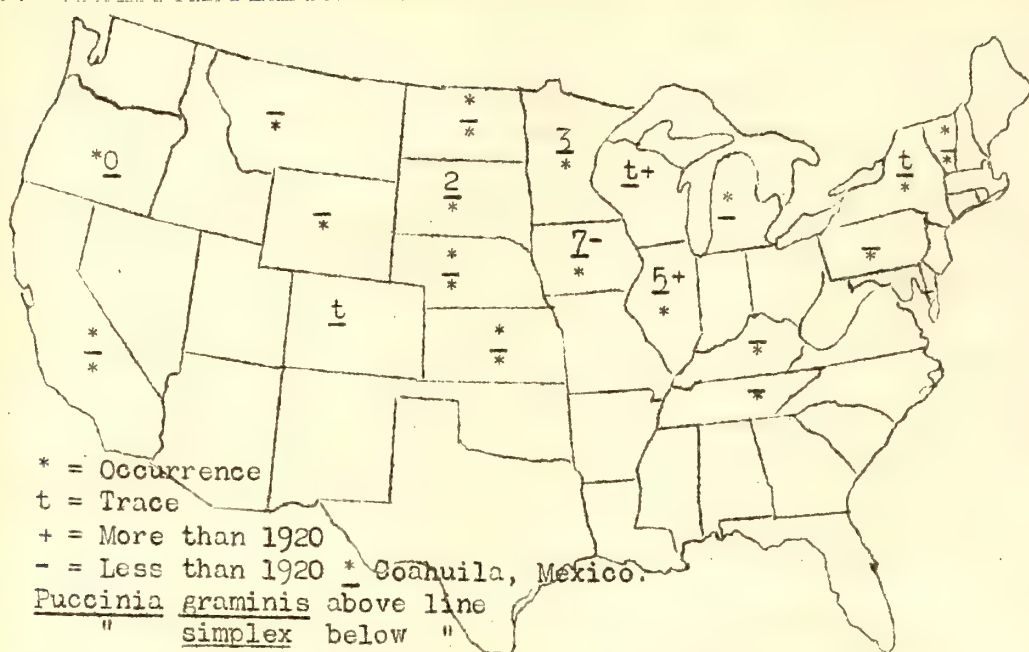


Fig. 53. Occurrence of stem rust (Puccinia graminis) and leaf rust (Puccinia simplex) of barley during 1921.

Net blotch caused by Helminthosporium teres Sacc.

Helminthosporium teres was observed in eleven states: New York, Illinois, Michigan, Wisconsin, Minnesota, North Dakota, South Dakota, Montana, Colorado, Oregon, and California. Melhus estimated that the net blotch reduced the yield in Iowa by 5%. Evans reports that he had seen a dozen fields in South Dakota in which this disease had completely ruined the crop, and he estimates the reduction in yield for the state at 3%. The maximum percentage of the disease which he found in any one field was 100. The disease also was destructive in certain localities in Oklahoma as is indicated by the following memorandum from Dr. H. B. Humphrey to Dr. G. R. Lyman:

(Referring to specimens from Robert Stratton, station plot.)

"Specimen No. 7 consists of barley plants affected with net blotch. These specimens represent an unusually serious attack and if they are representative of the condition of the barley field from which they were taken, my recommendation would be to plow the whole thing under, in order to avoid the possible further spread of spores from such diseased material. Helminthosporium teres, as you know, has its perfect stage in a species of Pleospora."

Net blotch evidently was unimportant in the other states from which it was reported; only in Iowa, South Dakota, and in some localities in Oklahoma was it really destructive.

Stripe caused by Helminthosporium gramineum Rab.

Barley stripe occurred in the following states: New York, South Carolina, Maryland, Illinois, Wisconsin, Iowa, Minnesota, North Dakota, South Dakota, Nebraska, Colorado, Arizona, Idaho, Oregon, and California. It reduced the yield by 5% in Iowa and Utah; 3% in Arkansas; 2% in Minnesota and in South Dakota; but in all of the other states the losses were less than 1%. In South Dakota the highest percentage of diseased plants observed in any field was 30, while in Minnesota in one field 25% of the plants were affected, and in Indiana the maximum found in any one field was 5%. In Wisconsin, according to Vaughan, the disease was not important enough to warrant a campaign for seed treatment. Bolley observed that the disease has never been destructive in North Dakota and that it was seen only a few times in 1921. He states, however, that it could become quite destructive if barley culture were intensive or continuous. The following reference to an article by H. C. Miller and E. Molz may be of interest.

H. C. Miller and E. Molz. Ueber die Streifenkrankheit der Gerste und ihre Bekämpfung auf Grund neuer Versuche. Deutsche Landw. Presse 48: 419. July 16, 1921.

Spot blotch caused by Helminthosporium sativum P. K. & B.

Spot blotch was observed in New York (trace), Louisiana (trace), Michigan (common), Wisconsin (very slight), Iowa (trace), Minnesota (damage considerable, but estimate of percentage reduction almost impossible without more accurate survey), North Dakota (unimportant), Nebraska (moderate infection), Arizona (trace), Oregon (rare - no loss), and California (minor importance). Vaughan observes that in Wisconsin the disease was less prevalent than last year or than in an average year. He states that the injury is caused not only by the spotting of the leaves but also by seedling blight. In Minnesota also the disease is widespread both on the leaves and on other parts of the plant. The greatest damage is done by the attacks on roots, culms, leaves, and heads. The leaf spotting is only of minor importance compared with the effect of the root and foot rot and head blight. It is quite likely that the losses caused by this disease have been underestimated. The writer has seen many fields throughout the barley-growing regions of the central part of the United States in which serious damage was done by the disease. It was observed at the Minnesota Experiment Station by Hayes and others that some varieties of barley could not be grown profitably on a commercial scale on account of their susceptibility to Helminthosporium sativum. The rough-awned Manchuria barley is quite resistant to the disease, whereas, the smooth-awned Lion is extremely susceptible. Crosses have been made between the Manchuria and the Lion and some of the segregates combined the resistance of the Manchuria with the smooth-awned character of the Lion. There are great differences in the susceptibility of different varieties to the disease. A few of them are so susceptible that they do not head when the disease is epidemic. Some were observed in field plots at the Minnesota Station during this past summer on which symptoms resembled almost exactly those of the rosette (so-called take-all) of wheat in Illinois. While the spot blotch itself may be of rather minor importance it is the opinion of the writer that Helminthosporium sativum, on account of the fact that it causes a very destructive seedling blight as well as lesions of other parts of the plants of wheat, barley, and rye and many grasses, may be a very virulent and dangerous parasite. Control probably will be accomplished by the production of resistant varieties.

(Hayes, H. K. and E. C. Stakman. Resistance of barley to Helminthosporium sativum. Phytopath. 11: 405-411. Oct. 1921. (Feb. 1922).)

Scald caused by Rhynchosporium secalis (Heins.) Davis

Barley scald was reported only from Idaho, Washington, Oregon, and California. It apparently did not do much damage except in California, where the disease caused a reduction in yield of 10%, according to Mackie. Mackie states further that the disease injured all early-sown barley which he saw in field varieties in the Sacramento Valley, but the late sown varieties were less affected. Mackie mentions that Tennessee Winter barley, which is resistant to scald, is also able to survive excessive quantities of water in contrast to the common, or Coast barley which is severely injured under the same conditions. Heald and Dana state that in Washington blue barley was severely affected while adjacent plots of Tapp winter were not injured. Barss says that only winter varieties were found to be diseased in Oregon. Hungerford made observations on College Farm in Idaho, and found that the varieties were affected as follows: Wisconsin 57.9 to 65%, Tennessee Winter 15%, Michigan Winter 15%, and White Winter 15%. The yield of the Wisconsin variety was materially reduced, according to Hungerford.

Root rot caused by Fusarium sp

According to Mackie a species of Fusarium has been causing a destructive root rot of barley in California. The following excerpt is from a letter from him to G. R. Lyman:

"In nearly all the wheat and barley fields visited this year south of Davis, I found a Fusarium root rot causing more or less damage. In some instances the damage has been estimated at 20% of the crop. The damage usually is about 5% or less. The presence of the disease in the field is found to be indicated by the weakening of the culms, the death or early maturity of the plants and shrivelling of the kernels. The characteristic pink color on the roots and up some distance on the culms was found in nearly all instances. Inspection of samples under the microscope developed true Fusarium conidia. My identification was confirmed by Prof. E. H. Smith."

A seedling blight of barley caused by Fusarium culmorum, variety leteius, was described in an abstract by Jessie P. Rose. (Rose, Jessie P. A seedling blight caused by Fusarium culmorum var. leteius Shear. (Abstract). Phytopath. 12: 28. Jan. 1922.

Miscellaneous diseases

Anthraxnose caused by Colletotrichum cereale Manns. Taubenhaus reported that there was a trace of this disease in Texas.

Powdery mildew caused by Erysiphe graminis DC. - reported to be very prevalent in New York where, on account of the early warm spring, the damage reached 1.5%, according to Kirby; and was reported once in Oregon, in a moist draw in a field at Moro.

Leaf spot caused by Septoria passerinii Sacc. This has been reported from Wisconsin. (Weber, George F. Studies on Septoria diseases of cereals and certain grasses. (Abstract). Phytopath. 12: 44. Jan. 1922.)

Ergot caused by Claviceps purpurea (Fr.) Tul. Ergot of barley was found in Wisconsin, Iowa, Minnesota, North Dakota, and Montana. While it was present in several fields in some of these states, it was not found in amounts sufficient to be of economic importance.

Scab, caused by Gibberella saubinetii (Mont.) Sacc., was observed in Illinois, Wisconsin, Iowa, and Minnesota. In Minnesota the disease was fairly widespread, but did not cause any appreciable damage. The head blight is fairly common on barley, but it very seldom reduces the yield.

OATS



Fig. 54. Distribution of oats in the United States. (Map prepared in the Office of Farm Management.)

Smuts caused by Ustilago avenae (Pers.) Jens. & U. levis (K. & S.) Mag.

It is quite evident that the two smuts of oats, which are not separated in the survey, still do a great deal of damage in spite of extension campaigns for seed treatment. The map, Fig. 55, shows the distribution and percentage of reduction in yield due to oat smuts. The greatest losses apparently occurred in Texas and Arkansas. In both of these states it is estimated that the yield was reduced by 10% or more on account of smut. In Kentucky the yield, according to Valleau, was reduced by 8%. According to Ludwig, 7% is estimated as the reduction in yield for South Carolina; 6% in Oklahoma according to Stratton; and

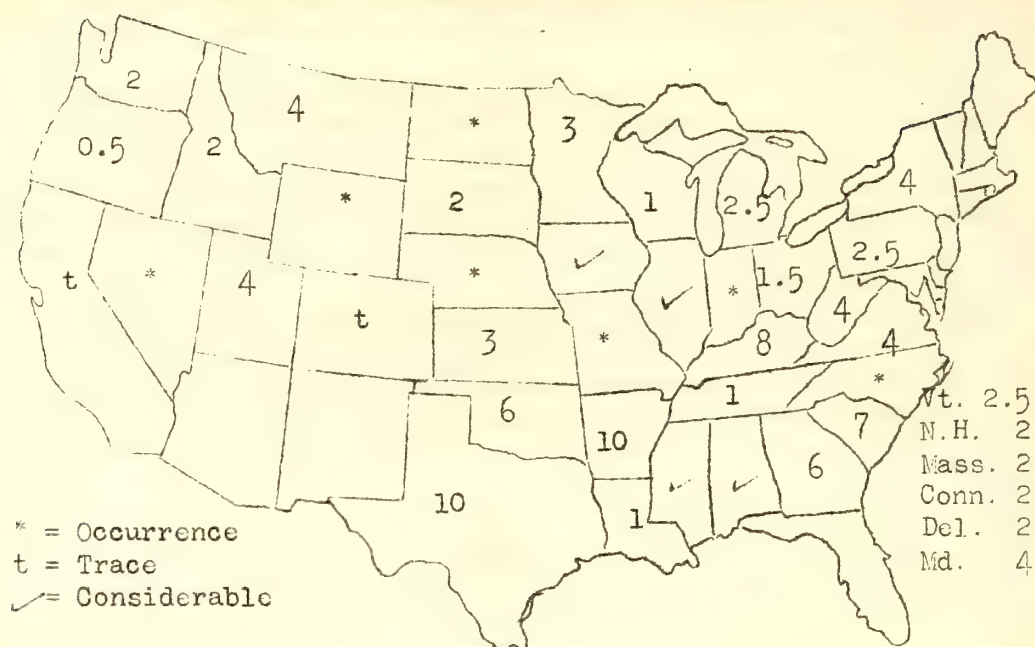


Fig. 55. Percentage reduction in yield caused by smuts of oats.

4% in Montana, according to Jennison. The highest percentages of smut found in individual fields are as follows: In Washington 40%, Indiana 35%, Kansas and Arkansas 30%; Vermont 20%, Maryland 20%, Connecticut, Kentucky, and South Dakota 15%. It is noteworthy that collaborators volunteer the information that in some states where the smut is very prevalent seed treatment is rarely ever practiced. For instance, both Valleau and Elliott comment on the fact that seed treatment is rather rare in their respective states. The percentage of smut in Kentucky was 8, while Elliott and Rosen state that it was 10% in Arkansas. Collaborators report that seed treatment is practiced commonly in New York, North Carolina, Ohio, Michigan, and Oregon. Barss says that seed treatment is so generally used in Oregon that smut is not commonly troublesome. Apparently soil conditions determine to a certain extent the amount of smut which develops in a crop. The relation of temperature, soil moisture and oxygen to the germination of the spores of *Ustilago avenae* and *U. levis* are given by Edith Seymour Jones in a brief summary, published in abstract form. (Abstract). Phytopath. 12: 45. Jan. 1922.

The results of experiments with chlorophol, a new disinfectant, are summarized by Tisdale as follows (Cereal Courier 13: 280-284. Dec. 30.):

"Chlorophol, a new disinfectant which was tested on smutted seed of *A. nuda* for controlling both oat smuts, gave almost perfect control with very little or no seed injury."

Other work on seed treatment is reported by Lambert and Bailey (2), and by Howitt and Stone (1); and L. J. Stadler writes in the Cereal Courier as follows:

The results of our preliminary tests of the effects of various formaldehyde treatments for oat smut are reported below. The object of this test was to obtain preliminary information on the effect of the various formaldehyde treatments now recommended by different stations on the yield of oats, aside from their effect in controlling smut. The treatments were therefore applied to Burt oats, which are commonly free from smut under our conditions. No smut was found in this plot either in the treated or the untreated rows. Five treatments were used in comparison with an untreated check, and the six lots of seed were each sown in single row rows replicated twenty times. The order of treatments was the same in each series. The yields were as follows:

<u>Method</u>	<u>Yield, bu. per acre</u>
Illinois (Ill. Circ. 240)	50.3 ± 0.98
Old treatment, oats covered 14 hrs. (Farmers' Bul. 939)	54.8 ± 1.00
No treatment	48.3 ± 1.09
Old treatment, oats covered 5 hrs.	54.1 ± 1.00
"Iowa" treatment (Iowa Circ. 45.)	52.9 ± 0.97
Atomizer method (Phytopathology 7: 381-383.)	53.9 ± 1.31

None of the treatments noticeably affected the germination of the seed as determined either in germination tests or from the stands in the field. Apparently significant increases in yield were caused by most of the treatments, though of course several more trials must be made before any definite conclusions can be drawn. (Stadler, L. J. (Columbia) Cercal Courier 13: 288. Dec. 15.)

Fromme made some observations on varietal resistance, and the results summarized as follows:

General and about the same as usual in severity. Winter varieties, all seed untreated showed following percentages in Experiment Station plots: Virginia Grey, 15%, Fulghum 5%, Bancroft 5%, Appler 3%, and Red Rust Proof, 0."

Literature cited

- Howitt, J. E. and R. E. Stone. Experiments with Haskell's method or the so-called dry formaldehyde treatment for the prevention of oat smut. (Abstract). Phytopath. 12: 35. Jan. 1922.
- Lambert, E. B. and D. L. Bailey. Results of treating seed of spring wheat and oats with copper carbonate dust to prevent smut. (Abstract). Phytopath. 12: 36. Jan. 1922.

Stem rust caused by Puccinia graminis Pers.

Stem rust evidently was not as generally distributed as crown rust, as will be seen by the accompanying map (Fig. 56). Neither did the stem rust cause such great reductions in yield. However, it was quite generally present in the more northern oat-growing states. In the extreme South the stem rust seems to be much less important than the crown rust, while in the northern states, stem rust did the greatest damage. In Michigan and South Dakota, for instance, stem rust is reported to have reduced the crop by 10%, while in Minnesota the loss was about 5%. (See map, Fig. 56, for losses.)

Stem rust was found by Butler and Christopher on Phalaris caroliniana and Lemnodia arkansana in Texas and Oklahoma. Apparently both of the oat rusts are quite generally distributed on these hosts in the South.

A rather remarkable fact in connection with the distribution of these two rusts is brought out by Edgerton who states that he never has seen stem rust in Louisiana, although crown rust sometimes makes it impossible to grow oats successfully in that state. No explanation can be offered for this except that from the results of studies so far made in the rust epidemiology work, it seems that the urediniospores of crown rust are capable of overwintering more easily than are those of stem rust. Differences in varietal susceptibility possibly may account for the distribution of the two rusts.

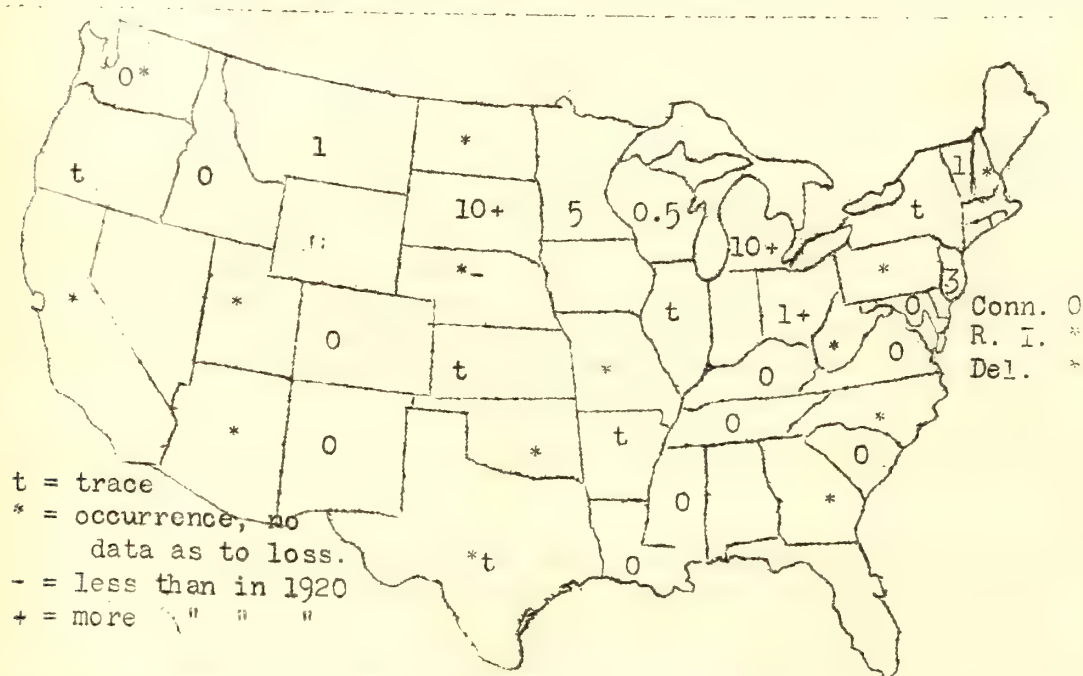


Fig. 56. Losses from stem rust of oats, 1921.

It scarcely seems that temperature relations are the determining factor, since stem rust is sometimes fairly heavy in Texas.

In the northern states White Russian oats are very resistant. The ordinary spreading panicle oats very frequently are heavily rusted while adjacent fields of White Russian are practically free from rust. An important study of the inheritance of resistance in crosses between resistant White

Literature cited

- Crown rust caused by Puccinia coronata Cda.

Fig. 57. Estimated percentage loss from crown rust of oats, 1921

Apparently the urediniospores of the rust overwintered in the South this year. Crown rust was fairly abundant at Brownsville, Texas, in January, and had appeared at Dallas, Texas on April 9. By the middle of May there was a heavy epidemic on oats in the general region of Dallas. In Texas and Oklahoma rust was found to be fairly prevalent by Butler and Christopher on Phalaris caroliniana and Lernodia arkansana. These grasses, as well as several others may

enable the uredinial stage of the rust to overwinter. The rust attacked the oats early in the South. Edgerton states that in Louisiana crown rust sometimes injured plants so severely that they did not head. He also observes that much seed was brought in from Texas, all of which was severely injured. Home grown seed was not so severely injured. Taubenhaus states that the Texas Red Rust Proof was decidedly susceptible this year, possibly due to the wet season. Melchers comments that for the first time since 1913 there was a tendency for the production of a real epidemic of crown rust in Kansas. The estimated reduction in yield is indicated on the map, Fig. 57.

It is interesting to note that several collaborators comment on the effect of buckthorn on the severity of rust. Browning states that in Rhode Island buckthorn is very common and abundant and aecial cups were noted early in the spring. Coons states that rust was very common and destructive in Michigan and that the native Rhamnus alnifolia was found to be rusted. Vaughan comments as follows: "In the vicinity of Rhamnus hedges in Dane and Rock Counties (Wisconsin) oats were almost a complete failure." In south-eastern Minnesota the effect of Rhamnus on the destructiveness of crown rust also has been noted. The wild Rhamnus alnifolia which is common in swamps often is heavily rusted, but apparently much of the rust on this host transfers to Calamagrostis canadensis but not to oats.

During the year several important publications have appeared. Hoerner has shown that the crown rust from oats can infect one or more species of the following genera of grasses: Agropyron, Alopecurus, Anthoxanthum, Arrhenatherum, Avena, Bromus, Dactylis, Elymus, Festuca, Holcus, Hordeum, Hystrix, Lolium, and Phleum, and Durrell and Parker have summarized the results of varietal tests.

Recent literature

- Durrell, L. W. and J. H. Parker. Comparative resistance of varieties of oats to crown and stem rusts. Iowa Agr. Exp. Sta. Res. Bul. 62: 27-56d. Illus. Oct. 1920 (Oct. 1921).
- Hoerner, G. R. Germination of aeciospores, urediniospores and teliospores of Puccinia coronata. Bot. Gaz. 72: 173-177. Sept. 1921.
- _____ Miscellaneous studies on the crown rust of oats. Amer. Jour. Bot. 8: 452-457. pl. xxiv. Nov. 1921.
- _____ Infection capabilities of crown rust of oats. (Abstract). Phytopath. 12: 33. Jan. 1922.

Halo-blight caused by Bacterium coronafaciens Elliott (= Pseudomonas avenae Manns)

Halo-blight was observed in thirteen states during the past year (see map, Fig. 58). It was fairly generally distributed throughout the country, except in the New England states and in the extreme South. It was recorded from Delaware, Kentucky, North Carolina, Arkansas, Ohio, Wisconsin, Minnesota, South Dakota, Iowa, Nebraska, Montana, Colorado, Idaho, and California. Apparently the halo-blight was quite prevalent but relatively unimportant. It was reported as having been very prevalent in Kentucky, North Carolina, Arkansas, Minnesota, South Dakota, and Montana. In Minnesota as many as 95% of the plants in individual fields were affected. In Montana apparently the disease was prevalent enough to cause some concern in the early summer. However, according to Jennison, it

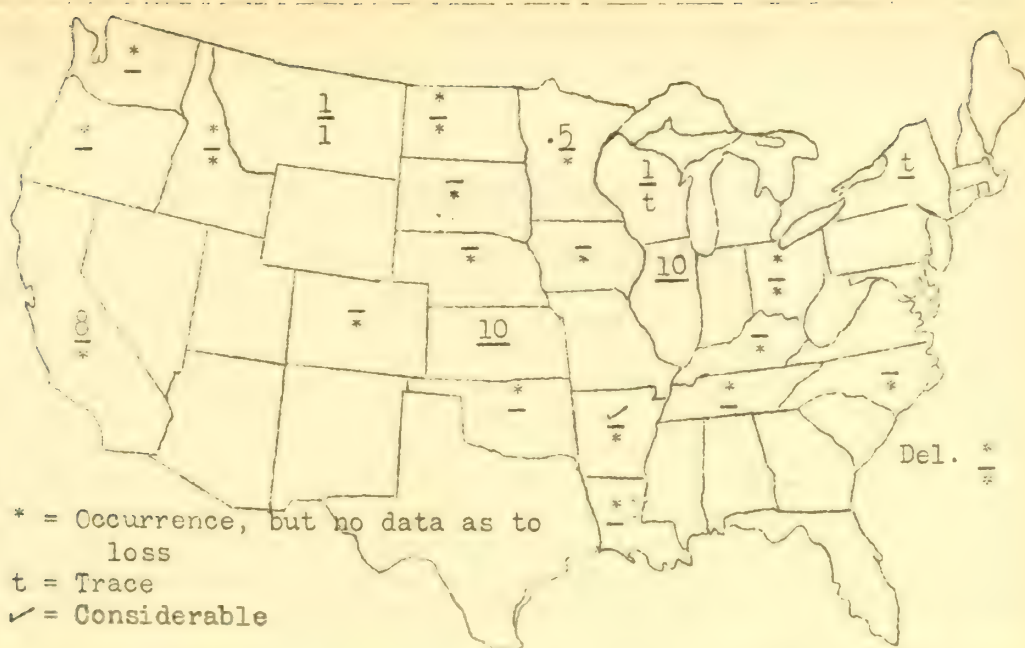


Fig. 58. Losses from blast (upper figures) and halo-blight (lower figures) of oats in 1921.

was checked by hot weather and caused a reduction in yield of only 1%. Various other collaborators comment on the fact that the disease was quite prevalent early in the season but that its spread was checked by the advent of hot, dry weather. Except Montana, where the yield was reported to be reduced by 1%, the damage was apparently negligible.

Blast (sterility) cause not determined

Oat blast was widely distributed through the country, as is shown on the accompanying map, Fig. 58, on which the occurrence of halo-blight also is recorded. The blast was most prevalent and did the greatest damage in Arkansas, Illinois, Kansas, and California. In Kansas as many as 80% of the heads were affected in one field. In most of the other states besides those already mentioned the disease occurred, but apparently did not do very much damage. Some observations are made by collaborators on the effect of weather on development of blast. Heald and Dana state that, according to Frank, there is much blast in western Washington each year, due to nutritional or climatic causes. Bolley suggests that it is associated with intensely hot weather just at the period when the flowers are being pollinated in the sheath, and Vaughan states that in Wisconsin the occurrence of blast is correlated with the emergence of the head from the boot in rainy weather. Apparently anything which interferes with pollination or fertilization is likely to cause blast.

Anthracnose caused by Colletotrichum cereale Manns

The anthracnose of oats was reported only from North Carolina, Ohio, and Minnesota. The disease did practically no damage in any one of these states.

Foster states that the disease was unimportant in North Carolina, and the same was true in Minnesota. In Ohio the disease was said to be of only slight importance.

Scab caused by Gibberella saubinetii (Mont.) Sacc.

It is quite evident that scab occurs only rarely on oats. It was reported only from Illinois, Iowa, Minnesota, Missouri, and North Dakota. Tehon and Dungan state that it was slightly more prevalent than usual in Illinois. In Minnesota there was a trace. Hopkins states that in Missouri there were several fields in which 50% of the plants had one or more infected spikelets. Frear writes, in a letter to the Plant Disease Survey that, in the inspection of fields in the pure seed work in Missouri, it was necessary to reject many fields on account of the prevalence of scab. Bolley and Weniger state that in North Dakota seedling blight was reported twice. They do not state whether the head blight occurred. It is quite likely that the scab head-blight occurs fairly commonly, although only in relatively small amounts. No detailed information was furnished regarding the seedling blight caused by the scab organism.

Miscellaneous diseases

Leaf spot caused by Septoria avenae Frank (see Weber, George F. Studies on Septoria diseases of cereals and certain grasses. (Abstract). Phytopath. 12: 44. Jan. 1922.)

Leaf mold caused by Cladosporium sp. - reported from Washington by Heald, Dana, and Frank.

Powdery mildew caused by Erysiphe graminis DC. - reported from Washington by Heald, Dana, and Frank; and from Coos County, Oregon by Barss.

Red leaf, probably due to cold and drought, reported by Fromme as being general in a field in Brunswick County, Virginia. According to Barss, it was more or less general in western Oregon, where it was apparently associated with soil and weather conditions.

Root rot, cause not determined, reported from Ohio as follows:

This apparently is a new disease of oats that has been brought to our attention for the first time this year. The field characteristics are a stunting and yellowing of the plants. It appears in irregular spots in the fields. When diseased plants are pulled up the root system is found to be very scanty, with a few remaining roots in a much decayed condition. The trouble was reported by Mr. Cave, the Fulton County Agent. Growers having this disease state that the same spots appear in the fields each year that oats are planted. Other crops such as corn, wheat, and clover, are not affected. (Clayton).

Frost and drought injury is reported from Washington and Missouri; probably also occurs in a number of other states. The intensely hot weather and accompanying drought in many regions undoubtedly was responsible for reducing the yield materially. Selby states that this was the most important factor for reducing the yield in Ohio.

CORN

Fig. 59. Distribution of corn crop in the United States. (Map prepared in the Office of Farm Management.)

Smut caused by Ustilago zeae (Beck.) Ung.

Corn smut in general was much more prevalent in 1921 than it has been for some years past. This is not true for all of the states, nor does it seem to be true for any particular region, but many collaborators comment on the fact that an unusually large amount of smut developed. In Rhode Island only a few specimens were obtained, all of which were on Golden Bantam. Clinton reports that in Connecticut there was about the usual amount, and that in Dr. Jones' breeding plots certain strains were quite resistant and others susceptible, and that these characters seemed to be inherited. Polley calls attention to the fact that the smut was quite common in certain fields in North Dakota, in a region which is rather new to corn, and suggests that either the spores must be carried long distances by the wind or the crop is infected by the use of diseased seed. Wind distribution probably easily could account for the appearance of the disease in new regions since large numbers of smut spores were caught at elevations of several thousand feet in the air, and since they are known to retain their viability for a long time. The greatest reduction in yield due to smut was reported from North Carolina where it was estimated as 20%. Evans estimates the reduction in yield in corn for South Dakota due to smut as 15% and comments as follows:

"Corn smut very bad. Never saw it worse. Many farmers declare it has ruined crops. No field free. Evidently excellent weather conditions when air conidia were distributed."

Learn states that in Colorado corn smut is becoming more prevalent each year and that in Lincoln and other counties the county agents report that it is very destructive. In Minnesota the smut unquestionably was much more prevalent and destructive than it has been for many years, although it is doubtful whether the yield was reduced by more than 2 or 3%. Many farmers and county agents

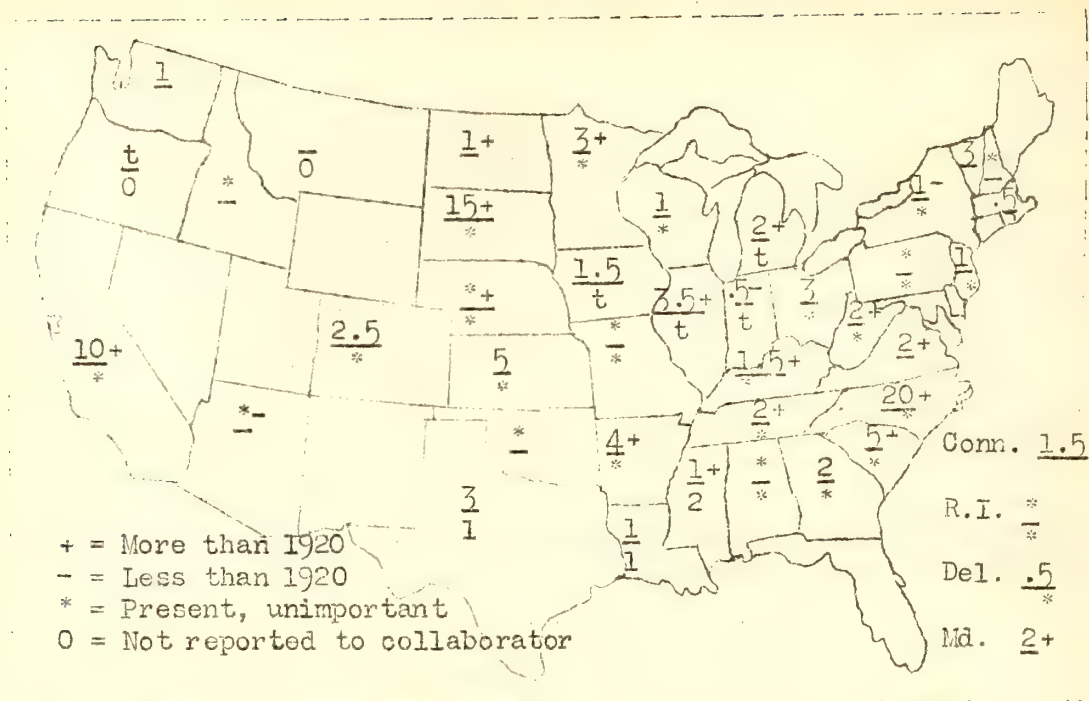


Fig. 60. Occurrence of and percentage losses from smut (upper figures) and rust (lower figures) of corn, 1921.

commented on the fact that in many fields as high as 75% of the plants were affected. The smut was so prevalent that fields appeared to be spotted with black when viewed from a railroad car window. (For losses and distribution see Fig. 60.)

There are differences in varietal susceptibility; even some farmers reported that they had observed differences. Cooperative experiments between the plant breeding and plant pathology departments at the University of Minnesota have been carried on for several years and it has been definitely established in corroboration of Jones' results at Connecticut, that there are differences in varietal susceptibility, and it seems that it will be quite possible to produce smut resistant varieties.

Just why the smut was so much more prevalent in many states this year than for several years past, cannot be explained easily. It would seem that in many localities the weather conditions were unfavorable for the development of the disease. However, this can scarcely have been true, since the fact of the unusual prevalence of the disease is unquestioned.

Rust caused by Puccinia sorghi Schw.

The rust of corn was very generally distributed. It was reported from most of the states in which corn is grown - from Rhode Island to California, and from Minnesota to Louisiana. It probably was almost universally present, although in the aggregate it causes very little injury. Browning states that in Rhode Island there was much less rust than there was last year but that there was a rather high percentage on Evergreen Bantam. Other varieties, according to Browning, were almost free from the disease. Neal states that in

Mississippi the disease was important locally, being rather severe in Adams County. He estimates that the yield for the state was reduced by 2%. Edgerton calls attention also to the seriousness of the disease in Louisiana. It was universally prevalent in the state, according to Edgerton, and caused death of leaves and sterility. Edgerton estimated that the reduction in yield for the state was about 1%. In Texas the rust apparently also did some damage. Taubenhuis estimates that the loss probably was 1%. In all of the other states, however, only a trace is reported, although many collaborators comment on the fact that the disease was unusually prevalent during the past season.

Root, stalk & ear rots caused by various organisms

Corn root, stalk and ear rots were quite prevalent and destructive during the past year. The accompanying map (Fig. 61) shows the distribution and the estimated reduction in yield. Fromme states that in Virginia the

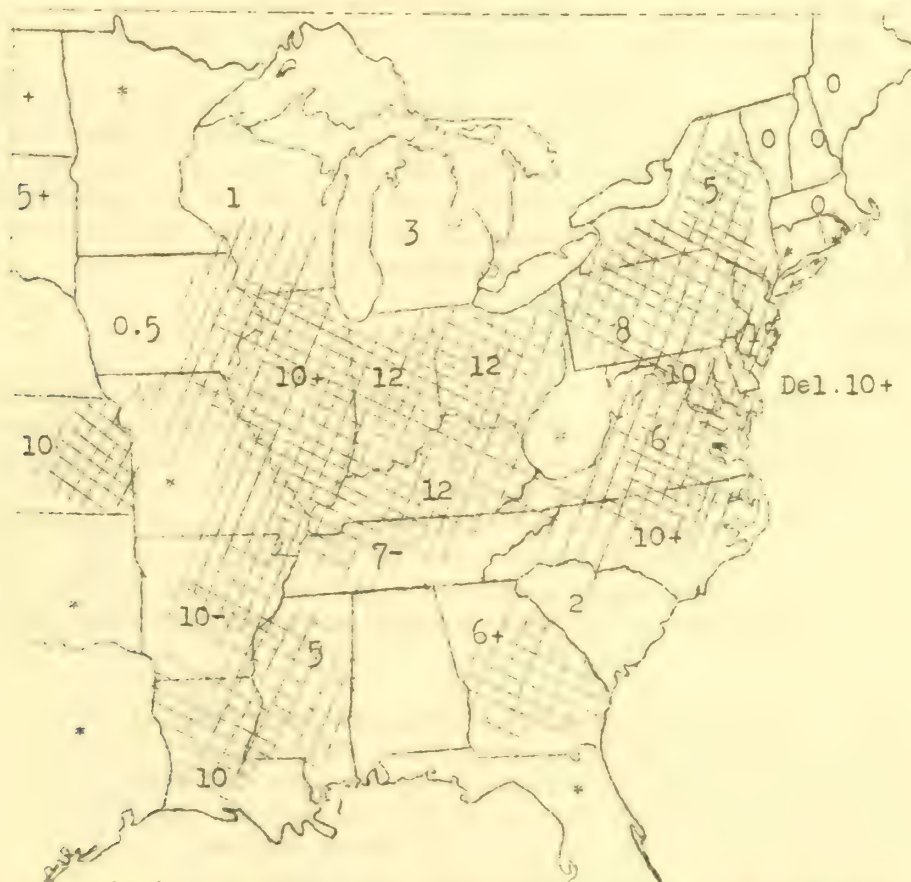


Fig. 61. Occurrence of and percentage loss from corn root, stalk and ear rots caused principally by Fusarium spp. Shaded area indicates region in which the disease is most important.

symptoms were not so evident as in previous years, but that the disease was present to some extent in all fields and that it was particularly prevalent in the Shenandoah Valley. Valleau comments that in Kentucky the disease is co-extensive with the crop, but that it is extremely difficult to estimate the losses from this type of disease. He states that the injury was serious where

there was insufficient moisture and food for the best growth of the corn plants, and that these diseases probably are of slight importance when the corn plants are growing under most favorable conditions. Holbert comments as follows on the situation in Illinois:

Mr. S. D. Fessenden of the Bureau of Crop Estimates in speaking of Illinois corn conditions among other things, says "Barren stalks are found unusually common, and badly filled ears are making great inroads into the individual estimates of farmers on their own crops." The organism connected with this type of trouble has been isolated in great abundance this year and is probably responsible to an appreciable extent for the numerous barren stalks and stalks producing nubbin ears. Harvest data taken on 1740 stalks inoculated with this organism show approximately 25% reduction in the total field weights. The data also show that certain varieties of dent and sweet corn are much more susceptible to this malady than others.
(J. R. Holbert. Cereal Courier 13: 241. Oct. 20, 1921.)

In Minnesota the root rot was fairly common in the southern part of the state, but apparently it did but little damage. It was observed that the disease was most destructive on poorer soils, and that when the corn was growing under favorable conditions root rots seemed to be of very slight importance. The disease was found in Idaho although, according to Hungerford, only one or two cases were reported and apparently it is of little importance.

Etiology of root rots

The etiology of the corn root rots is extremely important. Apparently Gibberella saubinetii and Fusarium moniliforme are most commonly associated with the disease. Edgerton states that in Louisiana Fusarium moniliforme is very common but that he has been unable to form any conclusion as to the damage it does to the crop. Holbert also states that F. moniliforme occurs commonly in Illinois, particularly following the ravages of the corn ear worm. He says that selections of Reid's Yellow Dent corn show wide variations in susceptibility to ear rot. The following summary on the etiology of these diseases was prepared by Dr. G. N. Hoffer:

"The greater number of ear rots and root rots of corn are caused by the same organisms, but it is necessary to discuss them separately because the contributing factors which determine the extent of the damage that results to the ears and roots varies according to the parts of the plant affected.

"Ear rots are dependent upon definite moisture and temperature relations, while the root rots seem to be most closely correlated with the quantities of certain nutrients and deleterious substances which are absorbed from the soil solution.

"(A) Root rots: The causes of rots of the roots of corn plants must be considered in their relation to

the normal functioning of the root system and the growth of the corn plant. The life of the roots is dependent upon the ability of the green parts of the plant and the translocation tissues to maintain an adequate number of them in a healthy condition for proper functioning. Every corn plant which has reached maturity has some roots which are rotted. The difference between a healthy and a diseased plant in so far as the extent of root rotting is concerned is one of degree only. A plant is regarded as being healthy so long as the root rots do not interfere with the production of well matured ears on apparently normal stalks of an adapted strain of corn.

"Resistance to root rots is a function of the genetical composition* of the plant and of the relative availability of deleterious substances which may be present in the soil solution, or which may become available in the immediate environment of the roots at some time during the life of the plant. Other soil conditions associated with deficiencies of any of the essential nutrients may also influence the growth of the corn plant and predispose it so that the roots may become severely rotted if the pathogenes are present in the soil, and proper temperature and moisture relations prevail.

"Aluminum and ferrous-iron salts are probably the most important deleterious agents which become available in the soil solution to affect the growth of the corn plant. In many soils aluminum compounds are available in sub-toxic quantities and the rate of their accumulation and consequent effect upon the living cells in the leaf and stalk tissues of the plants seem to determine the degree of susceptibility of the plants to serious rotting of the roots. The genetical composition of the plants as reflected in their varying physiological selective absorption capacities for aluminum compounds seems to be correlated with their relative susceptibilities to root rot when sub-toxic quantities of available aluminum are present in the soil solution. When, however, the quantities of available aluminum reach toxic proportions in the soil solution, all plants, irrespective of genetical composition, respond to this toxicity and the roots become thoroughly rotted. The acidity of the soil solution and the lack of available phosphates or frequently, potash, seem to be related to this soil influence upon the plants.

*In using the term genetical composition it is understood that the commercial varieties of corn represent combinations of strains which can be isolated by inbreeding. Inbred strains have been produced which show all gradations of susceptibility to root rots.

"The organisms which have been isolated from rotted roots on both "diseased" and "healthy" plants are most commonly Fusarium moniliforme, Diplodia zeae, Gibberella saubinetii, and Penicillium sp. The severity of the root rots caused by these organisms is dependent upon the relative susceptibility of the corn plant at any stage of its development, either as a seedling, a young plant, or a plant which has reached the post-pollination stage.

"(B) Ear rots: The development of the rots of the ears is determined primarily by the climatic complex affecting the ears and also by the condition of the stalk during the latter part of the season. If the stalks are affected by abundant root rot, the rate of maturation of the ears is inhibited. Such ears remain immature, or starchy, for a longer period, and are more affected by the ear rot pathogenes under adverse weather conditions than are those which are more matured.

"Corn ear-worms and hail may open channels of entry into the ears for the pathogenes, and thus favor an early development of the ear rots.

"The ear rots may develop irrespective of the serious rotting of the roots of the plants on which the ears are borne. The resistance of plants to root rots does not guarantee freedom from infections and infestations of the ears, although the ears which are borne on healthy stalks are more likely to be better matured and hence escape the attacks of the organisms. Some of the rots may progress to such an extent as to completely decompose the kernels and produce a badly rotted ear. Other infections and infestations may be inconspicuous. None of the organisms associated with the root rots have been found to be systemic to date, and consequently the ear rots are not caused directly by the growth of the organism from the roots upward through the stalk and shank.

"The pathogenes responsible for causing ear-rots and ear-infestations are Diplodia zeae, Gibberella saubinetii, and Fusarium moniliforme. Their importance as agents causing seedling blight depends upon the injury they do to the kernels before planting, as ear-rot organisms, and the relative resistance of the seedlings as determined by their genetical composition when they grow from kernels on ears which are thoroughly matured but infested by the organisms. Some ears may not be infested by any of these organisms, yet when planted will produce a high percentage of seedling blight and stalks with rotted roots. Other ears which are infested may give perfect stands and productive plants.

"Unless actual injury to the kernels on the ears has occurred the importance of seed infestations varies with the different strains of corn. The strains which are most affected by deleterious substances in the soil are the ones most seriously injured by seedling blight as well as by a rotting of the roots later in the season.

Summary

"From our present knowledge of root rots, it appears that they are primarily the resultant of the effects on corn plants of unbalanced supplies of available nutrients in the soil. Under such conditions plants are rendered more or less susceptible according to their varietal and genetical composition. When the soil environment is made physically and chemically favorable and uninfected seed of good strains planted, root rots are of little consequence because of the inability of the organisms which are commonly present in the soil to make progress in causing serious root rots even though the temperature and moisture relations are favorable for the development of root rots."

Control of root and ear rots

Very evidently control measures consist in the development of resistant varieties, careful seed selection, rotation of crops, maintenance of soil fertility, and various other cultural practices. Branstetter made some experiments in Missouri which are summarized in part as follows:

Rows planted from heavily, moderately, and lightly infected seed averaged respectively 27.4, 16.4 per cent of diseased plants while seed from the same lots disinfected averaged respectively 15.5, 12.5, and 8.9 per cent of the diseased plants. This indicates first, that the relative amount of disease in the field is roughly proportional to the root rot shown on the table germinator; and second, that disinfection of the seed as above described materially reduces the amount of root and stalk rot in the field. (B. B. Branstetter. Treatment of seed to control root and stalk rots. (Abstract). Phytopath. 12: 30. Jan. 1922.)

The effect of seed selection is shown by the following excerpts:

Illinois: In the plants which have been harvested so far, the disease-free seed has yielded much better than the diseased seed, the highest yielding disease-free producing at the rate of slightly over 100 bushels to the acre." (J. R. Holbert. Cereal Courier 13: 230. Oct. 10.)

Kansas: The plats of Pride of Saline corn planted from relatively disease-free ears made a significantly higher yield than those planted from diseased ears, while in the case of Midland Yellow Dent the difference in yield of the two plants was probably not significant. (John H. Parker. Cereal Courier 13: 292-293. Dec. 15.)

Recent literature

Clayton, E. E. Seed corn as a source of root rot infection. Cereal Courier 13: 278-279. Dec. 30, 1921.

- Hoffman, I. C. Report of corn root and stalk rot investigations 1919. Rep. Dept. Plant Path. New Jersey Agr. Coll. Exp. Sta. 1919/20: 598-604. 1921.
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- Kirby, R. S. The improved rag-doll germinator box. (Abstract). Phytopath. 12: 30. Jan. 1922.
- Manns, T. F. and J. F. Adams. Corn root rot diseases. Delaware Agr. Exp. Sta. Bul. 128.

Prevalence and distribution of fungi internal of seed corn. Science n.s. 54: 385-387. Oct. 21, 1921 (No. 1933).

Bacterial wilt caused by Aplanobacter stewartii (EFS) McCul.

The present status of bacterial wilt of sweet corn is well summarized in an article by Rand and Miss Cash (Rand, F. V., and Lillian C. Cash. Stewart's disease of corn. Jour. Agr. Res. 21: 263-264. May 16, 1921). The following is a brief summary of the article:

Found in Georgia, South Carolina, Tennessee, Virginia, Kentucky, Missouri, Iowa, Illinois, Indiana, Ohio, Pennsylvania, District of Columbia, Maryland, Delaware, New Jersey, southern New York, and Connecticut. Reported by other pathologists from Massachusetts, West Virginia, Michigan, Oklahoma, New Mexico, and California.

Arrangement of varieties according to time of maturity coincides almost exactly with arrangement according to percentage of wilt development. Later varieties show lowest percentages (average below 10%); earliest varieties under same conditions show serious losses (average 25-57%).

No evidence of infection from soil or from proximity to diseased stalks obtained; but organism isolated from endosperm of seed from diseased plants.

Infection of young plant from seed dependent on growth conditions during first two weeks - soil moisture, texture, fertility, and temperature, particularly soil moisture.

Results indicate that northern-grown seed is less likely to carry infection than that grown farther south, and that infected seed may be rendered safe for planting by a dry heat pasteurization at 60° to 70° C for one hour.

During the past year the disease was reported in Maryland, Virginia, Tennessee, North Carolina, Ohio, Indiana, Illinois, and South Dakota. Apparently it did no appreciable damage in most states. The loss is estimated as only a trace in all except in Maryland in which it is estimated as 1%. It was particularly abundant on Golden Bantam corn, especially in fields which had been planted early.

Brown spot caused by Physoderma zeae-maydis Shaw

This disease was most prevalent in the southeastern states and some of the states of the Ohio Valley. It was found as far west as Arkansas but did not occur to any extent in the more northern corn-growing states. The damage in the individual states was only a trace, although it was locally destructive. In Georgia, according to McClintock, the disease was serious but no definite figures indicating percentage of reduction in yield are available. Burger states that in Florida the disease was locally very destructive and he comments as follows:

"My observations are that in the southern part of the state the disease is not very severe. I believe that this is due to the fact that the corn is planted early and is matured before the rainy season comes on. However, in the northern and western parts of the state where the corn does not mature until after the rainy season, I find a considerable amount of damage being done. I visited a field in the northern part of the state where there was only a slight amount of spotting at the end of May. The spotting was so slight that I had to hunt through the corn field to find it. I went back to this field on about the 15th of July, the month of June having been somewhat rainy, and I found at that time the corn badly affected. The leaf and stalk showed that in two months' time this disease had so badly spread that much damage was found. In a neighboring field in Alachua County, on July 15 I found a lot of corn so badly affected that the stalks were breaking off about six inches from the ground, the tissue seemingly having been decayed. In many fields I found the disease on the husks about the time of ripening. In a lot of those ears where the disease was found on the husks, I found poorly developed ears, with loose grains, and I was wondering whether or not this is the one characteristic which is manifested by the disease. I also found on some ears a lot of grain poorly developed. I have kept some of this corn and hope that I will be able to plant it this coming spring and see if this corn does not carry the disease.

"In Putnam County, our adjoining County, one man reported from Hawthorne that his fields were so badly affected that if he did not soon get relief or some method for control, he would have to abandon the growing of corn on his property. He states that this disease has been getting worse for the past three or four years."

In Alabama, according to Povah, the disease was much less destructive than it was in 1920, possibly on account of the dry weather.

Mosaic, cause unknown

The mosaic disease of corn was reported in 1921 from Louisiana and

Georgia, and mosaic-like troubles occurred in North Carolina and Tennessee. In Louisiana Edgerton estimated that the reduction in yield due to the disease was approximately 2.5%. The disease in that state was considered by Edgerton to be considerably more prevalent than it was last year, or than it is in an average year. McClintock states that in Georgia also the disease was more prevalent than it was last year, or than it is in an average year and that it was spreading into south Georgia. The following statements made by Kunkel indicate that the mosaic disease is important in Hawaii:

I note that mosaic is present on corn in some of the southern states. It is one of the diseases that should be kept under observation. If it should spread to the corn growing regions of the Middle West and should there become one-half as destructive as it is in Hawaii, it would be a calamity. (L. O. Kunkel. News Notes, Office of Cotton, Truck and Forage Crop Disease Investigations. Aug. 6, page 7.)

The following summary is from Kunkel's bulletin dealing with a possible cause of corn mosaic.

1. A foreign body believed to be a living organism is invariably present in diseased cells of mosaic corn plants.
2. The body is irregular in shape and always occupies a position on or near the host cell nucleus. It usually shows a definite structure, stains like protoplasm and is frequently vacuolate.
3. The distribution of the intracellular bodies corresponds exactly with the distribution of the light green color in diseased leaf tissue. In the stalk, they are present in the cells of diseased tissues but absent from the cells of healthy tissues.
4. It is suggested that the bodies of corn mosaic may be similar to those associated with certain virus disease of man and animals.
5. Corn mosaic is similar to, if not identical with, the yellow stripe disease of sugar cane.
6. Nine varieties of sweet corn, two varieties of pop corn, and fourteen varieties of field corn have been shown to be susceptible to the disease. Several varieties are somewhat resistant but no variety is known to be immune. (L. O. Kunkel. A possible causative agent for the mosaic disease of corn. Hawaiian Sugar Plant. Assoc. Exp. Sta. Bul. 3 (1). July 9.)

Bacterial stem rot caused by Bacterium sp.

The bacterial stem rot of field corn was first described from Arkansas by Rosen (1,2). What appears to be the same disease was observed in the following states during the year: New York, North Carolina, Mississippi, Louisiana, Arkansas, Ohio, and Illinois. The collaborators from the following states

report that they have not observed the disease: New Hampshire, Vermont, Connecticut, New Jersey, Maryland, Virginia, West Virginia, Kentucky, Tennessee, South Carolina, Georgia, Texas, Oklahoma, Indiana, Michigan, Wisconsin, Minnesota, Missouri, North Dakota, Nebraska, Montana, Colorado, Arizona, Idaho, and Washington. It is quite likely that it may occur in some of these states but that it is not destructive enough to attract attention.

The bacterial stem rot did not seem to do much damage during the past year. It is listed as a trace in practically all of the states reporting it. Neal says that it occurred locally in Mississippi, while Rosen states that in Arkansas it was severe in certain places. Dungan and Tehon report that it was present in Illinois, especially in the southern part. The comment by Edgerton, among those quoted below, is especially interesting:

Louisiana: The bacterial stem rot of corn described by Rosen from Arkansas has been known in Louisiana since 1908. I saw it the first year that I was in Louisiana and have seen it to some extent nearly every year since. Some years it is very troublesome in some localities and other years, it is of little importance. There was some complaint this year on some of the reclaimed soils in south Louisiana. (Edgerton).

Ohio: A new type of stalk rot disease has been observed in Ohio. This is thought to be due to a bacterium species of organism although the identity of the causal factor has not been fully established. This type of disease has been found in different sections of the state during the seasons of 1920 and 1921. (R. C. Thomas).

Illinois: A few days ago I received two samples of corn - one from Jackson County and one from Monroe County - which showed typical symptoms of the bacterial stalk and root rot disease as described by Prof. H. R. Rosen, of Arkansas. I furnished him specimens of this disease from both of these counties and he has reported that without doubt it is the serious disease that occurs in Arkansas. It is the first occurrence of this trouble, as far as I know, in Illinois. Dr. Burrill, of course, did some work on the bacterial disease of field corn, but we are not able to learn definitely as to whether he was dealing with the same disease as the one that is showing up in these counties. (Dungan).

Literature cited

1. Rosen, H. R. A bacterial root rot of field corn. Ark. Agr. Exp. Sta. Tech. Bul. 162: 1-7. pl. 1-4. Aug. 1919.
2. _____ Further observations on a bacterial root and stalk rot of field corn. Phytopath. 11: 74-79. Feb. 1921.

Ear mold caused by Diplodia zeae (Schw.) Lev.

Ear mold caused by Diplodia zeae, was prevalent and destructive in 1921. It was reported only from New York, Ohio, Kentucky, Indiana, Illinois, and Iowa, but the percentage of reduction in yield was high in all states except New York,

The following are estimates of the percentage loss: New York (trace); Kentucky (8.5%); Indiana (10%); Illinois (8%); Iowa (4%). (The estimates for the last three states were made by Cromwell.) In Ohio, according to Thomas, the disease is causing serious concern, and while it was generally distributed it was most destructive in the southwestern part of the state. Valleau states that in Kentucky the disease is co-extensive with the crop. He states that there is definite indication that some pure lines of corn will be much more resistant than others. The following comments give an idea of the destructiveness of the disease in part of the corn belt:

Illinois: There is much rotten corn this year mainly due to secondary infections by Fusarium moniliforme following the ravages of the corn ear worm and to ear rots caused by Diplodia zeae. The season has been unusually favorable for infections by the latter organism. Selections of Reid's Yellow Dent from this locality and from other places in Illinois are showing wide variations in susceptibility to ear rots. (J. R. Holbert. Cereal Courier 13: 241. October 20.)

Iowa, Illinois, and Indiana: After a survey in parts of Iowa, Illinois, and Indiana I have placed the loss of corn from ear rots at 4, 8 and 10%, respectively. Diplodia zeae is responsible for about four-fifths of the loss. Various molds following ear worms and mostly restricted to kernels injured thereby or adjacent thereto are responsible for the remainder. (R. O. Cromwell, letter to Dr. G. R. Lyman, Oct. 25, 1921.)

Two abstracts of papers on the parasitism of Diplodia and conditions under which it develops have appeared recently:

Clayton, Edward E. Diplodia zeae as an ear and root parasite of corn. (Abstract). Phytopath. 12: 29. Jan. 1922.

Durrell, L. W. Diplodia of corn in Iowa. (Abstract). Phytopath. 12: 29. Jan. 1922.

Leaf spot caused by Helminthosporium turcicum Pass.

The leaf spot caused by Helminthosporium turcicum was reported only from Connecticut and Minnesota, although it very probably occurs in many states. The injury usually is negligible, and, in fact, is sometimes difficult to detect on account of the presence of other diseases. Clinton states that the disease was much more prevalent than usual in Connecticut and that it began to appear about the middle of August. It caused a certain amount of damage in some fields. In Minnesota the disease caused no appreciable damage although it was fairly prevalent.

Miscellaneous diseases

Leaf blight of sweet corn, probably caused by bacteria. Hungerford observed this disease on Golden Bantam corn in Idaho. It was present only in small gardens in the northern part of the state.

Ear mold caused by Cephalosporium sacchari Butler & Kahn. Manns and Adams called attention for the first time to the parasitism of this organism on corn in the United States. (Manns, T. F. and J. F. Adams. Prevalence and distribution of fungi internal of seed corn. Science n.s. 54: 385-387. Oct. 21. 1921. (No. 1399))

Head smut caused by Sorosporium reilianum (Kuhn) McAlp. The head smut of corn was found in Washington. According to Zundel, in one field near Pullman, 20% of the plants were infected. The disease also was found in Yakima County where considerable corn is grown. Dana states that the disease probably is spreading in Washington. No head smut was observed on corn in California although Mackie is of the opinion that it undoubtedly is present this year as it has been in the past.

Seedling blight caused by Helminthosporium sp. A species of Helminthosporium isolated from living corn plants, according to Stover, was found to cause a marked seedling blight of corn. The results of preliminary experiments are summarized in an abstract presented at the Toronto meeting. (Stover, W. G. The relation of soil temperature to the development of the seedling blight of corn caused by Helminthosporium sp. (Abstract). Phytopath. 12: Jan. 1922.)

RICE

Straighthead (non-parasitic)

Straighthead of rice was reported from South Carolina, Louisiana, Texas, and Arkansas, Fig. 62. Ludwig states that severe local injury probably occurred in South Carolina. Edgerton states that the disease was of considerable importance in Louisiana, although the aggregate loss probably was not very great. Taubenhau estimates that the yield was reduced by 5% in Texas, and Elliott estimates that the Arkansas yield was reduced by approximately 2%.

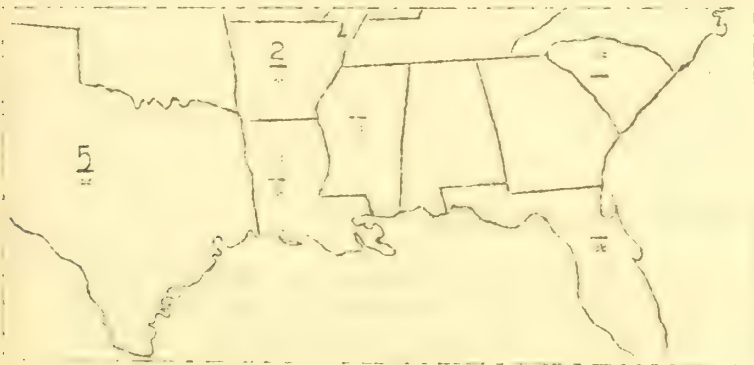


Fig. 62. Occurrence of and percentage loss from straighthead (upper figures) and blast (lower figures) of rice, 1921.

Blast caused by Piricularia oryzae Br. & Cav.

Rice blast was observed during the past year in Florida, Mississippi, Louisiana, Texas, and Arkansas. (See map, Fig. 62, under straighthead.) According to Burger it was reported from Florida, only in Manatee County, where it was said to be doing considerable damage. In Mississippi, according to Neal, it also caused some loss. Edgerton states that it is present throughout the

rice belt of Louisiana, but that it is of very little importance. Taubenhause states that losses caused by the disease in Texas also were negligible, while Elliott reports a trace of injury in Arkansas.

Miscellaneous diseases

Root rot caused by Pythium sp. is reported from Hawaii by C. W. Carpenter. (Carpenter, C. W. Morphological studies of the Pythium-like fungi associated with root rot in Hawaii. Hawaiian Sug. Plant. Assn. Exp. Sta. Bul. 3: 56-65. Aug. 1921.)

Sesame spot caused by Helminthosporium oryzae de H. previously reported from Japan, Java, Italy, and the Philippines, was observed by W. H. Tisdale in Louisiana during 1920, according to G. O. Ocfemia. This fungus is said to be identical with Piricularia oryzae Br. & Cav. (Ocfemia, G. O. The sesame spot disease of rice (Abstract). Phytopath. 12: 34. Jan. 1922.

Recent literature

- Farneti, R. Sopra il "brusone" del riso: note postume. Atti Ist. Bot. Univ. Pavia bv. 18. 14. p. pl. 20-21. 1921.
- Nishikado, Yoshikazu and Giichi Miyake. Momidane no shodoku narabini ine gomahagarebyo no yoboho (Disinfection of seed rice in relation to the prevention of Helminthosporium rice blight). (2) Ryusando ni yoru shodokuho (Disinfection by means of copper sulphate) Byochu-gai Zasshi (Jour. Plant. Prot.) 8: 498-506. Oct. 1921.)
- Sundaraman, S. Helminthosporium disease on "rice" (Oryza sativa). Yearbk. Madras Agr. Dept. 1920/21: 111-114. 1921.
- Tisdale, W. H. Two Sclerotium diseases of rice. Jour. Agr. Res. 21: 649-657. pl. 122-126. Aug. 1, 1921. (Aug. 26).

FLAX

Wilt caused by Fusarium lini Bolley

Flax wilt was found in Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota. Coons states that it was reported to be destructive in the fiber flax district in the "Thumb" of Michigan, although no definite figures on losses are available. In Wisconsin, according to Vaughan, at least one field in Kewaunee County was affected, but, since flax is not extensively grown in Wisconsin, the disease was not widespread. In Minnesota the disease was generally distributed, particularly on late planted flax. The injury ranged from a trace to 75%. The reduction in yield for the entire state is estimated at 7.5%. Brinsmade states that the flax wilt developed rapidly in North Dakota during the hot weather in June. He comments further, on July 20, that the combination of drought and heat was likely to ruin all the flax except that grown in cultivated nursery rows. (Cereal Courier 13: 142. July 20, 1921.) Bolley makes the following comment on conditions in North Dakota:

"The wilt diseases as usual have been rather evenly distributed, particularly in the eastern half of the state

on the old lands and have done damage in direct ratio to the plantings made on old lands. Most areas of wilt destruction were found upon lands already infested. Control has been quite evident on all those fields where proper wilt resistant stuff has been planted."

Evans states that the disease is general on old land in South Dakota. Jennison observed none of the disease in Montana, but he is of the opinion that some undoubtedly was present.

Flax wilt can be controlled easily by using resistant varieties. Several such varieties have been used in North Dakota for many years. At the Minnesota Station also resistant strains have been developed. The resistance is not absolute, and, if resistant flax is grown under conditions favorable for the fungus and unfavorable for the host, considerable wilt may develop.

Recent literature

Pethybridge, Geo. H., H. A. Lafferty, and J. G. Rhynehart. Investigations of flax diseases (second report). Jour. Dept. Agr. and Tech. Instr. Ireland 21: 167-187. April 1921.

Tochinai, Yoshihiko. Studies on the physiology of Fusarium lini. Trans. Sapporo Nat. His. Soc. 8: 19-44. 1921.

Rust caused by Melampsora lini Pers. (Desm.)

Flax rust was found only in the following states: Michigan, Wisconsin, Minnesota, and North Dakota. According to Coons, the disease probably was reported for the first time this year from Michigan. In Wisconsin it was reported only from Wood County while in Minnesota it was quite generally distributed, although it did practically no damage. According to Brentzel considerable rust developed on flax in North Dakota during August. "Most of the varieties and selections show some rust infection but some of the early maturing varieties developed with practically no rust." (Brentzel, W. E. Cereal Courier 13: 201. Sept. 10, 1921.) Bolley states that in some fields wilt resistant flax suffered badly from rust. In Minnesota the disease has rarely been of economic importance, probably on account of the fact that the variety of flax most commonly grown, Primost, Minnesota 25, is quite resistant to the disease.

Recent literature

Pethybridge, et al. (see under wilt).

Canker (non-parasitic)

The non-parasitic canker of flax was observed in South Dakota, but the injury was very slight, according to Evans. It occurred also in North Dakota where it was severe in some fields, according to Bolley and Brentzel, although it was less prevalent than it was last year and also less prevalent than it is in an average year. The maximum percentage found in any one field in North Dakota was 25, and the disease first appeared on June 10. In Minnesota the disease was found first in Polk County. It had not previously been observed, although it probably occurred. In one field 10% of the plants were killed.

Anthracnose caused by Colletotrichum lini Bolley

Anthracnose was not observed in any of the principal flax-growing states (Montana, North Dakota, Minnesota, Wisconsin, and Michigan), except in Michigan. Coons reported its occurrence at the Michigan Agricultural College.

Miscellaneous diseases

The following diseases of flax are described by Pethybridge, Lafferty, and Rhynehart (l.c.; see under wilt) as occurring in Ireland: seedling blight caused by Colletotrichum linicolum P. & L., foot-rot caused by Phoma sp., browning and stem-break caused by Polyspora lini n. gen. et sp., Sclerotium disease caused by Sclerotinia sclerotiorum, yellowing (non-parasitic), and Botrytis disease caused by Botrytis sp. These have not been reported for the United States.

Reference

- Lafferty, H. A. The "browning" and "stem-break" disease of cultivated flax (Linum usitatissimum) caused by Polyspora lini n. gen. et sp. Sci. Proc. Roy. Dublin Soc. n.s. 16: 248-274. Aug. 1921.

SORGHUM

Covered kernel smut caused by Sphacelotheca sorghi (Link) Clinton

Reported from New York; according to Chupp, one or two individual farmers reported that it was rather prevalent. Present in Alabama, 20% in experiment station plats according to Povah. Texas, 1% loss; Wisconsin, of minor importance, seed from south and southwest most heavily infected; seemed to be resistant strains of amber sorghum; no apparent injury to syrup production - Vaughan. In Kansas common in western and central regions, although it occurs in every county where sorghums are grown. Seed treatments gave almost perfect control - Stokdyk.

Loose kernel smut caused by Sphacelotheca cruenta (Kühn) Potter

The loose smut was reported only from Texas. Taubenhaus estimated that the reduction in yield due to the disease was approximately 2%. Kulkarni states that dwarf milo sorghum is resistant although not immune to grain smut, but that it is decidedly susceptible to loose smut. (Kulkarni, G. S. The susceptibility of dwarf milo sorghum to smut. Phytopath. 11: 252. June 1921 (Oct.)).

Head smut caused by Sorosporium reilianum (Kühn) MoAlp.

Head smut was reported only from Wisconsin, Minnesota, and Kansas. In none of these states did it cause serious losses, although sometimes it does

considerable damage. This year there was a considerable amount of it in some seed plots in Minnesota. The following statement summarizes the situation in Minnesota.

Ordinarily, smut is not a limiting factor in the sorghum syrup industry, but occasionally serious epidemics affect the color of the syrup (turning it an undesirable pink) and produce clouds of spores in the mills. This spore dust contaminates the syrup and becomes a general nuisance in the mill. Such an epidemic occurred in 1918. "Smut does not lower the sugar content of individual sorghum plants but its effect on yield per acre is unknown."

In 1921 infection was not general around Waconia, eighty percent of the fields being free from smut. In Willaman's seed plot, however, about seventy percent of the plants all Minnesota Early Amber, were infected. The strains in this field had been selfed for two years, and as sorghum is normally only about eight percent cross fertilized, some of these strains were nearly pure lines.

One strain, noted especially, comprising a fraction of a row, was completely free from smut, while the remainder of the row, and the two adjacent rows were so heavily infected that it would have been difficult to find a single clean hill in them. Seed from this apparently resistant strain, selfed for three years, is available for next year. (Willaman and Lambert).

Blight caused by Bacillus sorghi Burr.

Blight caused by Bacillus sorghi was found only in Delaware and Wisconsin. Collaborators in both states report that it was relatively unimportant.

DISEASES OF FORAGE CROPS

A. LEGUMES

ALFALFA

Leaf spot caused by Pseudopeziza medicaginis (Lib.) Sacc.

The Pseudopeziza leaf spot is widespread. It is reported from many states, as will be seen from the map, Fig. 64. It is quite likely that this leaf spot disease causes more damage than is sometimes supposed, although it is always difficult to estimate the reduction in yield caused by such a disease.

Vaughan observes that in Wisconsin the disease is worst on acid soils. Stokdyk states that the spot was severe in Kansas in fields which were not cut early. In Arizona, according to Brown, the disease is fairly well distributed but not very important. In Idaho, it is common wherever alfalfa is grown, according to Hungerford. Barss says that the disease is common, but not often serious, in Oregon. Mackie notes that in California the first crop sustains the greatest damage and that the succeeding crops are injured but little.

Yellow leaf blotch caused by Pyrenopeziza medicaginis Fekl.

The states from which the yellow leaf blotch was reported, together with estimates of injury, are indicated on the map, Fig. 63. While the disease was widespread, it apparently was not very injurious during the past season, except in Idaho. Hungerford states that it causes defoliation of plants, is common throughout the state, and that it is the most serious disease on alfalfa in Idaho. According to Hungerford, the first cutting is most severely injured. In Oregon, it is said to be most common in the semi-arid regions of the state.

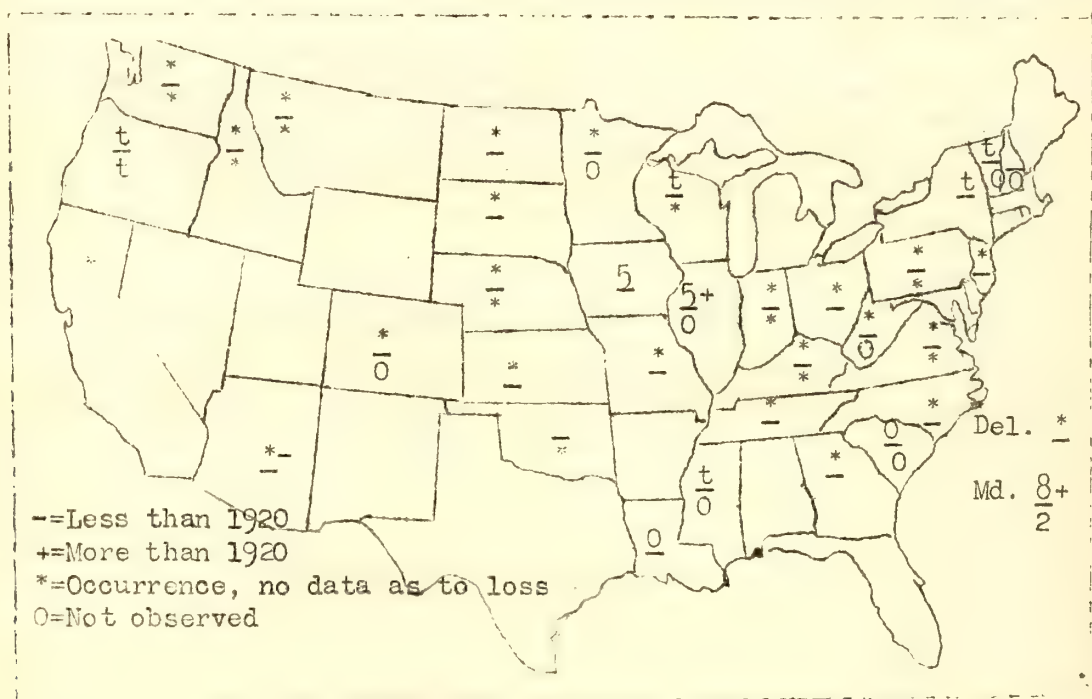


Fig. 63. Occurrence of and percentage losses from Pseudopeziza medicaginis (above line) and Pyrenopeziza medicaginis (below line) in 1921.

Rust caused by Uromyces medicaginis Pass.

Rust was reported from several states although it apparently did little damage in any of them. In North Carolina it was unimportant and occurred mostly in the Piedmont and Mountain counties; in Mississippi it was unimportant and occurred locally; in Louisiana the importance was considerable, according to Edgerton; in Texas there was a slight trace in the Rio Grande Valley. It

occurred also in Ohio, Indiana, Wisconsin, North Dakota, and Kansas. In Arizona, according to Brown, it was generally distributed but not important. The greatest aggregate damage apparently was done in California, where Mackie estimates a reduction in yield of 1%.

Anthracnose caused by Colletotrichum trifolii Bain

Anthracnose was reported from Arkansas and Mississippi as follows:

Arkansas: The disease was much worse than last year and also much worse than in an average year; 100% of the plantings in the state were infested and 95% of the plants were affected. There was continuous girdling of the shoots until the crowns and roots rotted. The host was affected in all stages of growth. The spring was very wet and the temperature was slightly above normal. Many fields were plowed and practically no hay was cut as the disease continued to kill the plants throughout the summer. A little hay was cut early. (Crawford and Elliott).

Mississippi: I have just received specimens of alfalfa from Sharkey County which are infected with anthracnose, Colletotrichum trifolii. This is of interest since Professor Beal says this is the first time to his knowledge that anthracnose of alfalfa has ever been reported from Mississippi. It is reported as causing considerable loss in a field of several acres at Anguilla, Sharkey County. (Neal).

Bacterial blight caused by Bacterium medicaginis Sackett

Bacterial blight was reported from Wisconsin (less severe than usual); Montana (about the same as usual); Colorado (unimportant); Arizona (less than usual, a few fields fairly badly injured); Utah (some damage); Idaho (more than usual, especially in southern irrigated sections); Washington (Whitman County); and Oregon (probably not very important).

Downy mildew caused by Peroospora trifoliorum de Bary

Downy mildew was reported from Virginia (slight damage in field at Blacksburg); Louisiana (little importance); Illinois (one field); Wisconsin; Kansas; Montana, Colorado; Idaho (due to wet spring, more prevalent than ever before); Arizona (trace); Washington; and Oregon (probably worse than usual, due to moist and mild winter and cool spring, not of great importance though coextensive with host). In none of these states was the aggregate damage great. Undoubtedly the disease occurred also in other states but it probably was not noticed on account of its relative inconspicuousness.

Root rot caused by Sclerotinia trifoliorum Eriks.

Slight damage was caused in Virginia. At Blacksburg from 2 to 3% of the plants were affected. In Kentucky apparently there was more than usual, particu-

larly on young plants. Valleau suggests that the open warm winter was favorable to the disease. In North Carolina it was most prevalent in the Piedmont counties. There was a trace of damage in Mississippi, in Arkansas, Wisconsin, North Dakota (one case only), two reports from Idaho, one from Bonners Ferry and the other from American Falls (first report of the disease from Idaho). In Washington it occurred in the Puget Sound region. In Oregon, according to Barss, it was worse than usual, and serious in many fields, occurring throughout the western part of the state. The following comments are made by various collaborators:

North Carolina: Sclerotinia wilt is destructive to alfalfa. Estimates of loss in individual instances have been noted and Sclerotinia wilt has frequently caused the grower to abandon the growing of clover and alfalfa. A field of clover and alfalfa in Durham County was so badly infested with Sclerotinia wilt that it was planted to other crops. (A. C. Foster).

South Dakota: A year or so ago a very serious crown rot appeared in the alfalfa and sweet clover during the late spring. Whether this was due to Sclerotinia trifoliorum or not I am unable to say. I have made examination for it this year but have found no trace of it. (Evans).

Root rot caused by Ozonium omnivorum Shear

This was reported from Texas in which Taubenhause states that it is so important as to prevent the growing of alfalfa in the heavy clay soils of the state. The only other state from which the disease was reported is Arizona. Brown states that it occurs in all alfalfa districts and that it can be detected throughout the year.

Miscellaneous diseases

Leaf spot caused by Cercospora medicaginis E. & E. - Slight traces reported from Texas.

White spot, cause unknown - reported from Casa Grande district in Arizona, and from Spokane County, Washington.

Yellow top - reported from southeastern Washington.

Violet root rot caused by Rhizoctonia medicaginis (DC.) Tul. - reported from Iowa.

Root rot, cause unknown - Hungerford reports the general presence in Idaho of a root and crown rot which appeared to be particularly severe on account of the cold, wet spring.

Root knot caused by Heterodera radicicola (Greef.) Müll. - reported from Texas, where, according to Taubenhause, it was unimportant. Taubenhause notes that the Hairy Peruvian variety is quite resistant and that it saved the crop in Webb County.

Tylenchus dipsaci (Kühn) Bastian - reported from Oregon by Barss who says that it caused considerable injury in at least one field on the campus at Corvallis. This is the first report of the disease on alfalfa in Oregon. According to Godfrey it occurs on this host in Idaho also.

Dodder (Cuscuta spp.) - reported only by Gardner from Indiana, but it

undoubtedly occurs in other states also.

Frost injury - reported as having been severe in Pennsylvania and Michigan. Coons states that Grimm and Cossock varieties were not wounded.

CLOVER

(White clover, Trifolium repens; red clover, T. pratense; alsike clover, T. hybridum; crimson clover, T. incarnatum)

Anthracnose caused by Colletotrichum trifolii Bain

Anthracnose was observed in the following states: Delaware - (unimportant); Kentucky (caused the death of plants in a considerable number of fields, large amount in some fields, caused a stem blight on crimson clover before blossoming time, and occurred also on young red clover; effect was aggravated by dry weather); Virginia (Concerning specimens collected at Arlington Farm by R. J. Haskell - I have received the specimen of clover anthracnose which you sent me a few days ago. This anthracnose is probably the same one that occurs upon clover in the Tennessee region and is not the one caused by the fungus, Gloeosporium caulivorum. The fungus on the specimens which you sent me is the Glomerella type.- Edgerton); Tennessee (on red clover, important but no definite figures on losses); North Carolina (not destructive); Ohio (importance slight, worse in the western portion of the state, infection most conspicuous and injurious on second growth crops - Young); Indiana (probably important); Illinois (red clover situation is average, disease has played an important part in clover failure, anthracnose being the most serious in my opinion - I do not have any information as to the losses that clover diseases may have caused - Dungan); and Wisconsin (minor importance).

Anthracnose caused by Gloeosporium caulivorum Kirch.

Anthracnose was reported as follows: Connecticut (Sheldon): I found the first that I have ever seen here May 4. Pennsylvania (Crton): Anthracnose is usually present in most fields of red clover and it is not uncommon to find it killing the stems of 5% of the plants. Ohio: Observed June 9, western Ohio, general but not serious in western and southwestern Ohio.

Leaf spot caused by Pseudopeziza trifolii (Bernh.) Fckl.

Leaf spot was reported from Vermont, New York, Pennsylvania, Delaware, Virginia, West Virginia, Kentucky, Ohio, Illinois, Michigan, Wisconsin, South Dakota, Washington, Oregon, and California, but it was of no particular importance in any of these states.

Powdery mildew caused by Erysiphe polygoni DC.

One of the noteworthy pathological features of the year was the unusual prevalence of clover powdery mildew. It was reported from the following states: New Hampshire (no material damage); Connecticut (reported for the first

time, inconspicuous and ascigerous stage not produced - Clinton); New York (very prevalent, made nearly every clover field in the state white; Seneca County, affected plants only half the size of the healthy ones; Suffolk County, quite common in red clover fields about Mattituck; and Sullivan County, general over county, severe - Chupp); New Jersey (abundant); Pennsylvania (general, but apparently doing little damage); District of Columbia; Delaware (general and important); Maryland (much worse than usual, particularly on second crop of red clover, estimated by Temple and Jehle to have reduced the yield of the late crop by 5% and to have reduced the entire crop of the state by 2%); Virginia (much more prevalent and probably quite destructive, most prevalent in south central part; more questions and complaints this year than all my previous six years in the state - Fromme); West Virginia (unimportant and occurring locally); Kentucky (more prevalent than usual, found practically in all fields examined, red and mammoth clover affected, crimson clover, alfalfa, sweet clover, Jap clover, trefoil, and spring vetch not affected, although in close proximity to red and mammoth clover - Valteau); Ohio (very much more prevalent than before although apparently not reducing in yield); Indiana (unusually prevalent, co-extensive with the host); Michigan (first appeared as common disease in 1921 - Coons); Wisconsin (less prevalent than usual, and unimportant); and Washington (observed in Whitman County).

Rusts caused by Uromyces fallens (Desm.) Kern and

U. trifolii (Hedw. f.) Lev.

According to Arthur (N. Am. Fl. 73: 254-255. 1912) Uromyces fallens occurs on red and crimson clover, while U. trifolii attacks alsike, crimson, and white clover. The distribution of the two species in North America is given as follows:

U. fallens: "On the subgenus Lagopus throughout the eastern United States and Canada from the Great Plains to the Atlantic Coast, and in one locality in the Selkirk Mountains (British Columbia)."

U. trifolii: "On the subgenus Trifoliastrum chiefly, from Newfoundland to Washington southward to the West Indies and central Mexico, rare in the southeastern states and on the Pacific Coast."

In 1921 most states reported only U. fallens without mentioning the kind of clover. According to E. B. Mains, however, U. trifolii occurred on white clover in northern Indiana, and Melhus reported this species on clover in Iowa. In both states it was apparently unimportant.

U. fallens was reported from Vermont, Connecticut, Pennsylvania, Delaware, Maryland, West Virginia, Kentucky, North Carolina (reported as U. trifolii on red clover), Louisiana, Arkansas, Ohio, Indiana (on crimson clover), Michigan, Wisconsin, Minnesota, North Dakota, Nebraska, Washington, and California. It was not said to be important, although rather generally distributed in many states, except in North Carolina, where Foster says that it is common and quite destructive, especially on red clover. In Indiana, according to Mains, "Italian seed produced resistant plants but they winterkilled badly."

Root rot caused by Sclerotinia trifoliorum Eriks

The Sclerotinia root rot was observed in Maryland (1% reduction in yield; 5% loss for crimson clover which is particularly susceptible - Temple and Jehle); Kentucky (apparently not serious on red clover but very injurious on crimson clover, alfalfa, and, during the past year, on sweet clover; aggregate damage slight - Valteau); Tennessee (important on red clover); North Carolina (3% loss (see also quotation below); Mississippi (trace); Wisconsin; and Oregon (worse; in general of minor importance, causing only slight reduction in yield. Occurs generally in western Oregon. Caused considerable damage locally. Bad on alsike clover; one case of damage to white clover in lawn reported - Barss).

The following report by A. C. Foster concerning the importance of the disease in North Carolina is of interest:

"I should say that by far the most destructive disease of both red and crimson clover is that of Sclerotinia wilt, this being reported from nearly every section of the state where clover is grown.

"Estimates of loss in individual cases have been noted and Sclerotinia wilt has frequently caused the grower to abandon the growing of clover and alfalfa. On the Station farm near West Raleigh, there is one such field, which was cropped to clover continually for several years until the wilt caused its death every year and the growth of clover was discontinued. In another instance a field of clover and alfalfa in Durham County was so badly infested with Sclerotinia wilt that it was planted to other crops."

Root rot caused by Fusarium sp.

Ohio: In the Plant Disease Survey reports we have a card for 1909 and 1910 referring to root rot of alfalfa caused by Fusarium roseum. About this time I find a reference to a stem blight of red clover due to F. roseum. (See also Ohio Bulletin 214, page 390, on red clover, and page 368 for root rot of alfalfa).

In Ohio Bulletin 203 the following statements were made:

"Infection experiments in the greenhouse (Pathologium) by use of cultures of Fusarium roseum Lk. from wheat, of Gibberella saubinetii (Mont.) Sacc. and of Fusarium roseum from clover, as well as sterilized dead scab kernels, showed a high death rate in the seedlings as a result of the infection. Infections by use of a mold fungus, Periconia pycnospora, gave about the same result as in the check portions.

"This infection work together with field work and cultures from clover stems indicate that Fusarium roseum Lk. is an active parasite upon red clover (Trifolium pratense L.) and is a cause of clover sickness in clover fields seeded after wheat. Evidence is also found in its parasitism upon alfalfa resulting in possible sickness."

We have certainly a marked outbreak of the trouble in Ohio for 1920 and 1921, and we are hoping to be provided with the necessary means for pushing our investigation of possible inter-relations in Fusarium diseases of cereals and forage plants. (A. D. Selby).

Very serious on T. medium, but other clovers not so much injured. Possibly same fungus as causes wheat scab and corn root rot. Some confusion with this trouble and injury from root borer. (M. J. Young).

Indiana: Root rot caused probably by a Fusarium severe in certain fields. (Gardner).

Wisconsin: A wilt of clover caused apparently by a Fusarium was found at Madison this summer. Damage from this source was slight. (Letter from Mr. Fred R. Jones, Dec. 8).

Root rots (causes undetermined)

The following comments on root rots are interesting:

Louisiana: The red clover is not a very important crop in Louisiana, due to the fact that it has to be grown as an annual. It dies out during the hot summer months. How much of this dying out is due to various root rots has never been determined. There is reason to suspect that Rhizoctonia and possibly other fungi have something to do with this. (Edgerton).

Ohio: Root rot has been reported as causing severe loss in that part of Ohio immediately to the southeast of Columbus. The men state that whole fields have died out, the trouble being most noticed at cutting time and after. Plants affected have the roots rotted entirely away.

Control measures have not been worked out, but it has been observed that mammoth and alsike clover are much less affected than is red clover. (Clayton).

Idaho: Rotting of the crown and roots. Reported from various parts of state in both irrigated and non-irrigated sections. (Hungerford).

Weather injury

According to the Market Reporter 4: 161, September 10, the extremely hot dry weather following the first cutting of the hay crop caused a considerable amount of injury, and the late spring freezes did some damage in central Illinois, northern and central Wisconsin, central Minnesota, northern Ohio, and northern Missouri. In Pennsylvania, according to Orton, crimson clover and red clover suffered severely from frost injury. Attention is called by collaborators in North Carolina and Maryland also to the injury done clover by the mild winter and the spring freezes. The following notes from Pennsylvania, concerning frost injury, and from Kentucky regarding winter injury, are of interest:

Pennsylvania: The red clover crop has generally been a failure in Pennsylvania this year. Thousands of acres were frozen during the early freeze which also hit the fruit crop severely.

This is the first time in my connection with Pennsylvania (nine years) that red clover has been seriously damaged by frost. It is quite evident that the weather in April brought the clover along too rapidly and made it susceptible to the freezes in May. So far as we can determine diseases did not play any important part in this year's loss to this crop. White clover is hardy. (Orton).

Kentucky: It is evident from the work of Professor Roberts of this Station who has done an immense amount of work in soil fertility in its relation to clover production, that the production of clover in this state is nearly entirely dependent upon the proper handling of the soil, and it would not be surprising if a similar situation were found throughout a considerable portion of the middle eastern states. The effect of lime and acid phosphate in the production of high yields of clover is very striking. I have gone over some of the fields and there is apparently little difficulty from the standpoint of disease in getting a good stand of clover. The principal trouble in this state from clover losses seems to be the inability of clover planted on certain soils being able to come through the winter alive. The soils which are untreated apparently heave the young clover plants out of the ground much more easily than in the treated soils. This is probably due to the fact that on the treated soils the root system is very much better developed than on the untreated portions, and in consequence, is not so readily disturbed. (Valleau).

Miscellaneous diseases

Leaf spot caused by Cercospora medicaginis E. & E. - observed in Delaware (for the first time) and in Indiana. Apparently it was not very destructive.

Leaf spot caused by Cercospora zebrina Pers. Bessey states that this was the most common leaf spot of red clover in Alpena County, Michigan.

Sooty spot caused by Phyllachora trifolii (Pers.) Fckl. - reported from Pennsylvania (common but not destructive); Virginia (very destructive in a few fields, especially on crimson clover); and North Carolina (one of the most common leaf spots and quite destructive to red clover).

Large leaf spot caused by Macrosporium sarciniforme Cav. - reported from Pennsylvania, Louisiana, Arkansas, and Ohio. According to Orton, it is prevalent but not destructive in Pennsylvania. Edgerton is of the opinion that this leaf spot may be the most common and most destructive one in Louisiana, where it sometimes causes severe defoliation. According to Elliott, it is relatively unimportant in Arkansas. According to Young, this is the first report in Ohio. The disease unquestionably occurs in other states also.

Mosaic (cause undetermined) - reported from Pennsylvania (on red clover but not on white), Illinois, Wisconsin. Apparently it was also prevalent in Quebec, Canada, according to Dickson and McRostie. (Dickson, B. T. Further studies on mosaic -I. (Abstract). Phytopath 12: 42. Jan. 1922. Dickson, B. T. and G. P. McRostie. Further studies on mosaic -II. (Abstract). Phytopath. 12: 42. Jan. 1922.)

Wilt caused by Sclerotium sp. Foster states that occasionally Sclerotium wilt is reported on clover in North Carolina.

Slime mold (Physarum cinereum (Batsch.) Pers.) - reported by Young from Ohio, damage negligible.

Nematode disease caused by Tylenchus dipsaci (Kühn) Bastian. Hungerford reports that this disease is very important in the Twin Falls section of southern Idaho. It was reported also from Coos County, Oregon. Barss says that it is not important, but that it may be more widely distributed in the state than is known at present. (See Godfrey, G. H. The stem and bulb infesting nematode in America. (Abstract). Phytopath. 12: 52-53. Jan. 1922, and Goodney, T. On the susceptibility of clover and some other legumes to stem diseases caused by the eelworm, Tylenchus dipsaci, syn. devastatrix, Kühn. Jour. Agr. Sci. 12: 20-30. Feb. 1922.)

Dodder (Cuscuta spp.) - reported from Indiana.

SWEET CLOVER (Melilotus spp.)

Damping off of young shoots caused by Corticium vagum solani Burt - Michigan.

Ascochyta stem canker caused by Ascochyta caulicola Laub. - causes blasting of seed in seed fields - Michigan. (Coons).

Mosaic (cause undetermined) - reported from New York, Pennsylvania, Indiana, Quebec (Dickson, l.c., see clover mosaic).

Anthracnose, probably caused by several fungi - Louisiana.

Crown rot and wilt, caused by Sclerotinia trifoliorum Eriks. - reported by Valleau to be injurious in Kentucky; and by Barss as bad in western Oregon.

Frost injury - reported by Heald and Dana from Washington.

MEDICAGO Spp.

Smut caused by Entyloma meliloti McAlp. on Medicago (Indica ?). The following excerpt is taken from a letter written by Fred. R. Jones. "Entyloma meliloti was found in Alabama in the latter part of March this year. The specimen was determined by Dr. J. J. Davis and is the first specimen of this fungus in the country of which we can find record."

Mosaic on Medicago lupulina. See Dickson, B. T. Further studies on mosaic -I (Abstract). Phytopath. 12: 42. Jan. 1922.

Anthracnose - Louisiana: The anthracnoses are not common. The legume anthracnoses need working over. There are a number of these forms which to me seem different. They occur on Melilotus and bur clover and may go to the red clover where this plant is grown on any scale. (Edgerton).

Leaf spot caused by Cercospora medicaginis E. & E. One record of occurrence in York County, South Carolina. Found in garden patch - unimportant. (Ludwig). The following report from Alabama is interesting:

The organism causing the leaf spot of bur clover is seed-borne. Dr. Hopkins, experimenting with various methods, found that by using hulled seeds he secured 100% healthy plants when the diseased seed were treated with 40% formaldehyde for 2 hours or with a 1:1000 mercuric chloride solution. Treated seeds were inoculated again after treatments. By treating the seed with hulls attached no satisfactory results were obtained. Dr. Hopkins' results will be published soon. (Thiel).

Powdery mildew caused by Erysiphe polygoni DC. - reported from Mississippi where it was unimportant but general in the eastern and northern counties, according to Neal and Miles.

COWPEA

Leafspot caused by Cercospora cruenta Sacc. - reported from Delaware (prevalent on older and lower leaves; first report for the state - Adams); Virginia (very severe damage reported from a field at Bowling Green - Fromme); Texas (prevalent, reducing the yield by approximately .5% - Taubenhaus); Arkansas (general and reducing yield by a trace); and Indiana (rare).

Leafspot caused by Amerosporium oeconomicum E. & T. - Delaware.

Leaf blight caused by Macrosporium sp. - Arizona.

Powdery mildew caused by Erysiphe polygoni DC. - The Oidium stage was found in June by Burger in Florida. The disease was observed by Gardner in a greenhouse in Indiana. Only the conidial stage was present.

Rust, caused by Uromyces appendiculatus (Pers.) Lev. - Virginia (black-eye is the only susceptible variety grown commercially in the state - Fromme); Texas (prevalent on fall plantings; caused a reduction of 1% in yield - Taubenhaus).

Mosaic (cause undetermined) - Arkansas.

Wilt caused by Fusarium vasinfectum Atk. - Virginia (severe damage; 20% in one field near Petersburg); South Carolina (prevalent and important. One kind affected was the garden variety, "Black-eyed pea". This is typically a sandy soil disease but during the last few years seems to be invading the Piedmont - Ludwig); Arkansas (scattered, but severe in some places; 2% reduction in yield - Elliott).

Root rot caused by Ozonium omnivorum Shear - Texas (8% reduction in yield - Taubert).

Rhizoctonia blight said to be due to Rhizoctonia dimorpha - reported by Matz from Porto Rico.

Root rot, cause unknown - reported by Ludwig from South Carolina.

Root knot caused by Heterodera radiculicola (Greef) Müll. - South Carolina (present in the northwestern portion of the state; typically sandy soil disease which seems to be becoming more important in the Piedmont - Ludwig); Arkansas (general; reduced yield of state by 10% - Elliott).

Sunscorch - reported by Adams from Delaware.

SOYBEAN

Bacterial blight caused by Bacterium glycineum Coerper and B. soiae Wolf - reported from Armstrong County, Pennsylvania; from the coastal plain region of North Carolina in which it was more prevalent than previously; from South Carolina where the reduction in yield was 1%; and from Louisiana, Indiana, and Michigan. (Shunk, I. V. and F. A. Wolf. Further studies on bacterial blight of soybean. Phytopath. 11: 18-24. Jan. 1921. (Feb.).)

Bacterial spot caused by Bacterium sp. - (Takimoto, Seito. Daidzu no saikinsei hantenbyo (Bacterial spotting diseases of soybean.) Byochu gai zasshi (Jour. Plant Prot.) 8: 237-241. May 1921.) Caused by a new bacterium not identical with B. glycineum, B. soiae, or Pseudomonas glycineum Nakano.

Sclerotium wilt caused by Sclerotium rolfsii Sacc. - reported from North Carolina where Foster states that it is important on the coastal plain, and from Louisiana where Edgerton estimates a reduction in yield for the state of from 1 to 2%.

Wilts caused by Verticillium sp. (possibly) and Fusarium sp., - according to Foster occur particularly in the Coastal Plain of North Carolina. There are striking differences in varietal resistance to Fusarium but not to Verticillium.

Mosaic (cause undetermined) - reported from North Carolina and Indiana. (Gardner, M. W. Soybean mosaic. Jour. Agr. Res. 32: 111-113. pl. 18-19. Oct. 8, 1921.)

Leaf spot, probably caused by a species of Macrosporium - reported by Gardner from Indiana where it appeared late in the season on Black Eyebrow, Dunfield and Ito San varieties.

VETCH

Leaf spot caused by Ascochyta pisi Lib. - reported from Delaware (first report in state).

Rhizoctonia root rot - reported from Washington.

HORSE BEAN (Vicia faba)

Mosaic (cause undetermined) - "Haricots (Vicia faba) suffered as much as 50% damage from mosaic in Quebec." (Dickson, B. T. Maladies des plantes en 1920-21. Ann. Rep. Quebec. Soc. Prot. Plants 13 (1920-21); 66-67. 1921.)

GUAR (Cyamopsis tetragonoloba Taub.)

Southern blight caused by Sclerotium rolfsii Sacc. - found in light sandy soils only (in Texas) causing a reduction in yield of 1%. (Taubenhaus).

B. GRASSES

Brown patch disease caused by Rhizoctonia solani Kühn

The brown patch disease, which was reported in September 1 issue of the Plant Disease Bulletin is sometimes injurious on lawns in Connecticut, according to Clinton, and appeared in New York also, where Chupp says that it is quite troublesome on golf courses.

Literature

Piper, C. V. and R. A. Oakley. The brown patch disease of turf. Bul. Green. Sect. U. S. Golf Assoc. 1: 112-115. June 1921.

Plant Disease Survey. Brown patch of turf caused by Rhizoctonia solani Pl. Dis. Bul. 5: 76. Sept. 1, 1921.

TIMOTHY

Rust caused by Puccinia phlei-pratensis Eriks. & Henn.

Timothy rust occurs practically throughout the United States, but it was apparently not very prevalent this year. It was reported from New York, South Carolina, Tennessee, Indiana, Minnesota, Iowa, Missouri, and North Dakota. The disease was said to be unimportant in New York and South Carolina, and to be less prevalent in Minnesota than for several years. H. D. Barker, who has been

studying the rust for several years, comments as follows on its occurrence in 1921:

"In general I might say that timothy rust, at least late in the summer, was very hard to find throughout Iowa, Illinois, and Indiana. I made several examinations of timothy fields while we were on our trip South and found timothy rust very scarce indeed. I do not know what the cause for this was, except possibly the dry summer or peculiar overwintering conditions last winter, but the fact remains that timothy rust seemed scarcer than usual during the past summer."

Smut caused by Ustilago striaeformis (West.) Niess.

Timothy smut was reported only from New York, where the disease was found locally on a private lawn, according to Kirby; and from Iowa and Minnesota where it apparently was fairly general but unimportant.

MILLET (*Panicum miliaceum*)

Head smut caused by Ustilago panici-miliacei (Pers.) Wint. - reported from Washington by Heald and Dana.

SUDAN GRASS (*Holcus sorghum sudanensis* (Piper) Hitchc.)

Anthracnose caused by Colletotrichum cereale Manns - reported from North Dakota. Severe on two large fields in which it occurred in connection with Bacillus sorghi. It was much more abundant than the bacterial leaf blight - Wanda Weniger.

Bacterial blight caused by Bacillus sorghi Burr. - South Carolina, North Dakota, and Washington.

Leaf spot caused by Phoma insidiosa Tass. - Arlington Farm, Virginia, Sept. 1920. (Koch, Elizabeth and Caroline Rumbold. Phytopath. 11: 345. Aug. 1921.

Smut caused by Sphacelotheca sp. - Washington.

MISCELLANEOUS GRASSES

The following organisms were reported on miscellaneous grasses as follows:

Claviceps purpurea

Agrostis alba - Wisconsin

Calamagrostis canadensis - Minnesota

Erysiphe graminisPoa pratensis - South Carolina, Minnesota,
Washington

Hordeum jubatum - Minnesota

Helminthosporium sp.

Agropyron caninum-Minnesota (Christensen)

Agropyron intermedium " "

Agropyron repens " "

Agropyron smithii " "

Agropyron tenerum " "

Alopecurus pratensis " "

Andropogon furcatus " "

Calamagrostis canadensis " "

Chaetochloa italica " "

Dactylis glomerata " "

Digitaria sanguinalis " "

Echinochloa crusgalli " "

Elymus canadensis " "

Elymus striatus " "

Elymus virginicus " "

Festuca elatior (Drechsler, Charles-Net

blotch of meadow fescue caused by
an undescribed species of Helmin-
thosporium. (Abstract). Phytopath.
12: Jan. 1922.

Hierochloa odorata-Minnesota (Christensen)

Hordeum jubatum-Minnesota (Christensen)

Muhlenbergia sp. " "

Panicum capillare " "

Phalaris arundinacea " "

Phragmites phragmites " "

Poa pratensis-Illinois, Minnesota

Setaria glauca-Minnesota (Christensen)

Sorghum halapense " "

Stipa spartea " "

Zizania palustris - Minnesota

Helminthosporium bromi

Bromus inermis - Minnesota

Ophiobolus sp.

Agropyron repens-New York (field; Kirby)

Bromus secalinus-Arkansas (Rosen)

Elymus spp.-New York (artificial inocula-
tion; Kirby)Festuca octoflora-Arkansas (Rosen; natural
infection)Hordeum pusillum-Arkansas (natural infec-
tion)Hordeum jubatum-New York (Kirby; artificial
inoculation)Ophiobolus sp. (continued)Hystrix spp.-New York (Kirby;
artificial inoculation)Lolium spp.-New York (Kirby;
artificial inoculation)Phalaris spp.-New York (Kirby;
artificial inoculation)Setaria geniculata-Arkansas (Ro-
sen, natural infection)Phyllachora graminis

Elymus canadensis-Minnesota

Elymus robustus "

Puccinia oeanothiTripsacum laxum-Arlington Farm,
Virginia (J. A. Stevenson)Puccinia coronata

Festuca elatior-New York

Lemnodia arkansana-Texas, Oklahoma
(Christopher and Butler)Phalaris caroliniana-Texas, Okla-
homa (Christopher and Butler)Puccinia glumarum

Elymus condensatus-Washington

Hordeum jubatum-Idaho

Puccinia graminisAgropyron repens-near barberry,
New York (Kirby), Minnesota.

Agropyron tenerum-Minnesota

Agrostis alba-near barberry, New
York.Dactylis glomerata-New York
(Kirby; near barberry)Hordeum jubatum-Minnesota, North
Dakota, South Dakota.

Elymus condensatus-Washington

Festuca elatior-New York

Lemnodia arkansana-Texas, Oklahoma

Phalaris caroliniana " "

Puccinia polysoraTripsacum latifolium - Arlington
Farm, Virginia (J.A. Stevenson)Sclerospora graminicolaSetaria viridis-New York (Hoerner)
Iowa (Melhus - reduction 5%),
MinnesotaSeptoria agropyri E. & E.

Agropyron repens - Wisconsin

Ustilago striaeformis

Poa pratensis - Minnesota

SUNFLOWER - Rust

SUNFLOWER

C. MISCELLANEOUS

Rust caused by Puccinia helianthi Schw.

Rust caused by Puccinia helianthi Schw. - reported from Illinois (general); Michigan (loss in silage value 10% - Coons); Wisconsin (less than usual, causing dropping of lower leaves - Vaughan); Minnesota (general and causing some damage); North Dakota (destructive to foliage on some varieties - Weniger); Colorado (present but unimportant - Learn); Arizona (reported from one locality but probably not common - Brown); California (Distribution general, importance slight).

The following reference summarizes work done in Minnesota on this rust: Bailey, D. L. Investigations on Puccinia helianthi Schw. (Abstract). Phytopath. 12: 44. Jan. 1922.

Wilt caused by Sclerotinia sp.

Montana: Serious in Gallatin County; reduction in yield for county 5%.

Canker formed at the crown causing wilt and drying. Occurred also in Bitter Root Valley. Canada thistle found infected. (Morris).

Idaho: Reported from several parts of the state, but unimportant. (Hungerford).

Washington: Reported from three counties in the eastern part of the state. (Heald and Dana).

Quite destructive in wet seasons. (Frank).

The disease also was apparently common in Canada. (See Bisby, G. R. Stem-rot of sunflowers in Manitoba. Scient. Agr. 2: 58-61. Illus. Oct. 1921).

BACTERIUM

Bacterial wilt caused by Bacillus solanacearum EPS

Smith and Godfrey found that sunflowers were susceptible to Bacillus solanacearum when inoculated artificially. (Smith, Erwin F. and Godfrey, G. J. Bacterial wilt of castor bean (Ricinus communis L.) Jour. Agr. Res. 21: 255-261. May 16, 1921.)

Mr. G. M. Darrow,
Horticulture & Pomology,
Bureau of Plant Industry.